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PETROLOGY OF GRANITOID ROCKS OF THE BOISDALE PENINSULA, CENTRAL CAPE BRETON ISLAND, NOVA SCOTIA

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ABSTRACT

Mapping and petrological studies of granitoid rocks in the Boisdale Hills have identified twelve lithologic units which range from diorite to leucogranite. These units are probably comagmatic and, on the basis of previously published radiometric age data, of late Hadrynian to early Cambrian age. They intruded metasedimentary and metavolcanic rocks of the Hadrynian George River Group and late Hadrynian Fourchu Group following the Avalonian Orogeny and appear to be nonconformably overlain by Middle Cambrian to Ordovician sedimentary and volcanic rocks. Devonian and Carboniferous sedimentary sequences nonconformably overlie all of these older rock units.

The largest granitoid units consist of biotite or biotite hornblende granodiorite. Most evolved are texturally distinctive bodies of syenogranite and leucogranite. The intrusive sequence is interpreted to be from mafic to felsic, although relations among the various intermediate lithologies are not completely clear. The rocks display the typical petrological features ascribed to I-type, calc-alkalic granitoids and hence the parent magmas are inferred to have been derived from a primitive deep crustal or mantle source. The bodies were emplaced at relatively shallow crustal levels, especially the syenogranite at the northeastern end of the plutonic complex. Major and trace element compositions of the rocks are consistent with those of other granitoid plutons of similar age in southern Cape Breton Island, although intermediate lithologies (granodiorites) are apparently more abundant in the Boisdale Hills than elsewhere.

The southeasternmost unit (Spruce Brook Pluton) is petrologically similar to the Coxheath Pluton, which is located outside the map area to the southeast of the Boisdale Hills. An especially distinctive feature of both plutons is a compositional range from diorite to granite within a small body. Because of these similarities, the Spruce Brook Pluton may be of particular interest as an exploration target since the Coxheath Pluton and associated volcanic rocks contain significant Cu-Mo mineralization.

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INTRODUCTION

PURPOSE

Granitoid rocks are abundant on the Boisdale Peninsula in central Cape Breton Island (Fig. 1). During the summer of 1980, these rocks were mapped and sampled for petrological studies. The purpose of this report is to describe the field relations, petrography and geochemistry of these rocks and to compare them to others of similar age in southern Cape Breton Island. This work is part of an on-going investigation of the geology and geochemistry of granitoid plutons in Cape Breton Island (Barr et al., 1979, 1982).

The granitoid rocks of the Boisdale region are of particular interest because of recent discoveries of tungsten mineralization in associated skarns (Chatterjee, 1977; S. Sears, personal communication, 1980) and because of the possibility of porphyry-type(?) Cu-Mo mineralization similar to that in the adjacent Coxheath Pluton (Fig. 1) (Hollister et al., 1974; Kirkham and Soregaroli, 1975; Pollock and Riddell, 1979). No detailed mapping and petrological studies of the plutonic rocks of the area have previously been undertaken.

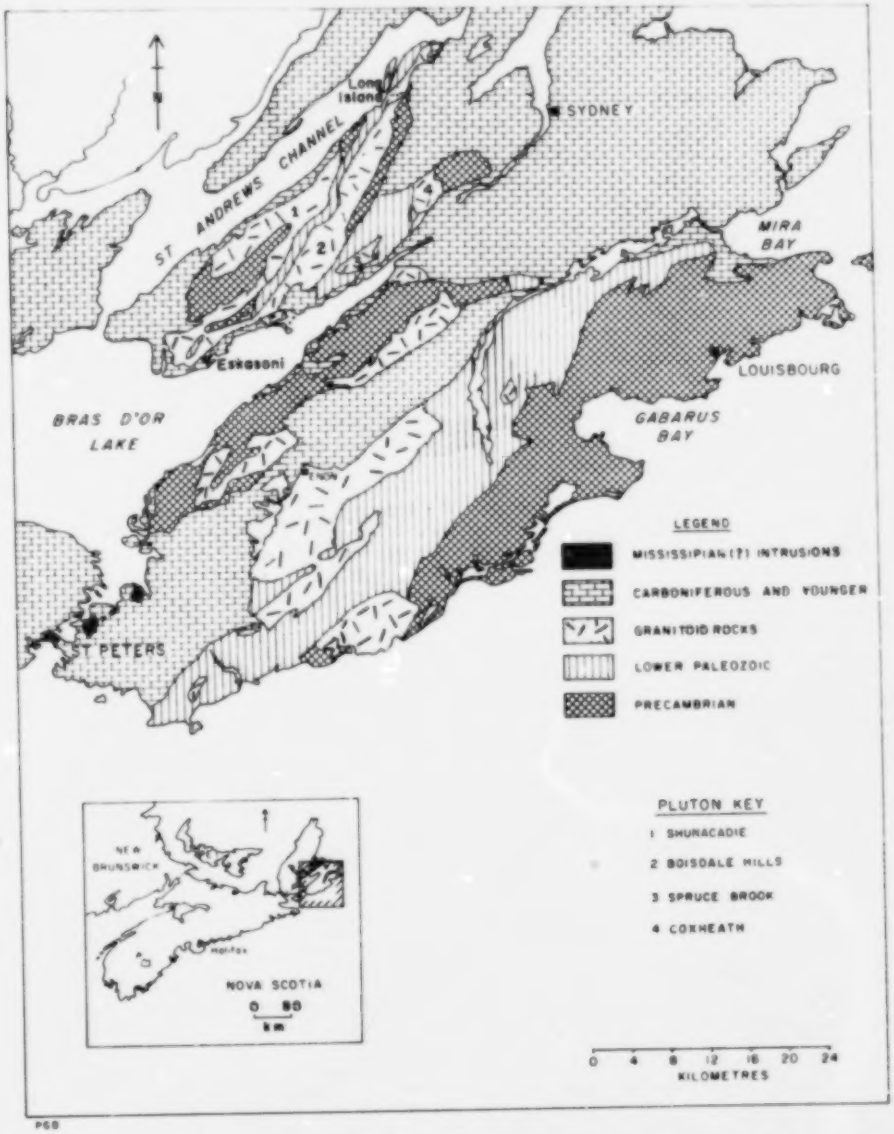

Figure 1. Simplified geological map of southern Cape Breton Island showing the location of plutons in the Boisdale Peninsula (modified from Helmstaedt and Tella, 1973; O'Reilly, 1977).

METHODS

The Boisdale Peninsula was mapped using contoured orthophoto maps (scale 1:10 000) published by the Nova Scotia Land Registration and Information Service as base maps. The northern part of the area was the subject of an M.Sc. thesis project by J. R. D. Setter (Setter, 1981), and was mapped and sampled in greater detail than the southern part. Outcrop distribution is adequate, with the best exposures in brooks and along road sections (Fig. 2).

A total of approximately 250 samples were selected for petrographic studies. From these, 70 samples were chosen for chemical analyses, on the basis of appearing to be representative of the main rock types, providing reasonable geographic coverage and showing the least intense petrographic evidence of alteration and weathering. Petrographic descriptions of the analyzed samples are given in Appendix A. Methods of sample preparation were as described by Barr et al. (1982).

Major element analyses were done in the Department of Geology, Acadia University, by atomic absorption spectrometry (Si, Ti, Al, Fe, Mn, Mg, Ca) and flame photometry (Na, K). Loss on ignition was determined as percentage weight loss after heating in a muffle furnace for one hour at 1000°C. Analyses were done commercially by the Chemical Laboratory for the Investigation of Minerals, Technical University of Nova Scotia, Halifax, for Fe^{2+}, P and the following minor and trace elements: Ba, Cu, F, Mo, Pb, Rb, Sn, Sr, U, W and Zn. Analytical results are presented in Appendix B. Discussion of precision and accuracy of the analyses are given in Appendix C. Details of the various analytical methods and further discussion of precision and accuracy are given by Barr et al. (1982).

Twelve samples representing the main granitoid rock types in the area were selected for analyses of feldspars, amphiboles and micas using the Cambridge Instruments Microscan 5 microprobe with Ortec energy dispersive multichannel analyzer at Dalhousie University, Halifax.

Most samples collected were tested with a scintillometer and an ultraviolet lamp, but neither anomalous uranium concentrations nor scheelite were detected.

PREVIOUS WORK

The Boisdale Peninsula was included in regional mapping by Bell and Goranson (1938), Weeks (1954) and Kelley (1967). They briefly described the plutonic rocks as ranging from gabbro and diorite to granite and syenite, with a variety of dyke rocks. Bell and Goranson (1938) considered the plutonic rocks to be late Precambrian or early Cambrian in age on the basis of the lack of crosscutting relations with adjacent Middle Cambrian sedimentary rocks and spatial association with the Precambrian George River Group (Fig. 1). However Weeks (1954) and Kelley (1967), as well as Hutchinson (1952), interpreted the granitoid rocks to have intruded the Cambrian strata and assigned them to the Devonian. Later, Milligan (1970) in his study of the George River Group in the Boisdale Hills considered the granitoid rocks to be pre-Ordovician.

The age question was largely resolved by radiometric dating (Fairbairn et al., 1960; Wanless et al., 1968; Cormier, 1972; Poole, 1980) which confirmed the interpretation of Bell and Goranson (1938) by giving essentially late Precambrian-early Cambrian ages for the granitoid rocks as discussed later in this report. Helmstaedt and Tella (1973) concluded that most of the plutonic rocks intruded the George River Group and have unconformable or faulted contacts, or both, with Middle Cambrian rocks, an interpretation compatible with the published age data and with the field observations of the present study.

The Coxheath Pluton to the east of the Boisdale Peninsula (Fig. 1) yielded both similar (Wanless et al., 1968; Cormier, 1972) and somewhat older (Stevens et al., 1982) radiometric ages, and is probably approximately contemporaneous with the plutons of the Boisdale Peninsula. The Boisdale Hills and Coxheath Hills areas have been the focus of numerous exploration programs, results of which are described in various assessment reports on file with the Nova Scotia Department of Mines and Energy, Halifax. Barite mineralization on the northwestern edge of the Boisdale Hills was described by Felderhof (1978).

GEOLOGICAL SETTING

GRANITOID ROCKS

Granitoid rocks on the Boisdale Peninsula occur in three more or less separate belts which trend approximately northeast-southwest, parallel to regional structural trends (Fig. 1). For purposes of description, these belts are referred to as separate plutons although, as will be shown, they are probably all part of a single plutonic complex.

The northwestern belt extends from Benacadie Pond northeast to St. Andrews Channel and is referred to as the Shunacadie Pluton, a name assigned by Poole (1980). The central belt also extends from Benacadie Pond northeast to St. Andrews Channel, but is largely separated from the Shunacadie Pluton by Cambro-Ordovician sedimentary and volcanic rocks. This belt is referred to as the Boisdale Hills Pluton, also following Poole (1980). Various parts of this pluton have been previously assigned other names (e.g. Mount Cameron Pluton, Eskasoni Pluton, and Leitches Creek complex of O'Reilly, 1977; Long Island Pluton of Cormier, 1972, Barr and Setter, 1981, and Setter, 1981; Loon Lake and Eskasoni Plutons of Barr and Setter, 1981), but these are not used in this report. The southwestern ends of the Shunacadie and Boisdale Hills Plutons, as here defined, have been previously included in the Eskasoni Pluton of O'Reilly (1977) and Barr and Setter (1981). Eskasoni is not a valid pluton name because it was much earlier assigned to a formation in the Bourinot Group (Bell and Goranson, 1938; Hutchinson, 1952). Furthermore

the rocks in the northern part of this area are petrologically similar to, and apparently continuous with, the Shunacadie Pluton (Fig. 2), with which they are included. The southern part, separated from the northern part by a belt of Cambro-Ordovician and George River Group rocks, is lithologically more similar to the Boisdale Hills Pluton, and hence is included with it.

A small pluton southeast of the Boisdale Hills Pluton is here named the Spruce Brook Pluton. Farther to the east is the Coxheath Pluton which was not systematically mapped during the present study, but which will be discussed to some extent because of its apparent similarity to the Spruce Brook Pluton.

GEORGE RIVER GROUP

The George River Group (Fig. 2) in the eastern part of the Boisdale Peninsula was described in some detail by Milligan (1970). It consists of interbedded quartzite, marble and minor slate which were deformed and subjected to low grade regional metamorphism (Milligan, 1970; Helmstaedt and Tella, 1973) during the Avalonian (Cadomian) Orogeny (Keppie, 1979). They were subsequently contact metamorphosed adjacent to the plutonic rocks, although the distribution of the contact aureoles has apparently been complicated by later faulting. The contact metamorphic mineral assemblages, as well as associated hematite, sulphides and scheelite in the area of Steele Crossing and to the northeast were described by Chatterjee (in Milligan, 1970 and Chatterjee, 1977).

The George River Group in the rest of Boisdale Peninsula has not been previously described in any detail. Along the southern margin of the Boisdale Hills Pluton, southwest of Steele Crossing and within the Pluton in the Eskasoni area (Fig. 2), the George River Group seems to be essentially a continuation of the quartzite/marble units described in Milligan (1970) and Chatterjee (1977), with possibly minor volcanic rocks present northwest of Eskasoni. However, George River Group rocks to the north, between the lobes of the Shunacadie Pluton (Fig. 2), are different and include a significant proportion of meta-igneous rocks (amphibolites) as well as quartzite, but apparently lack marble. Along the northern margin of the Shunacadie Pluton, the George River Group consists mostly of quartzites and meta-siltstones.

Details of the stratigraphy, structure and metamorphism of the George River Group are beyond the scope of this study, and represent a challenging project for future workers in the area.

FOURCHU GROUP

The Late Hadrynian Fourchu Group is a predominantly metavolcanic rock unit which is widely distributed in southeastern Cape Breton Island and inferred to overlie the George River Group (Weeks, 1954; Keppie, 1979). The Fourchu Group, like the George River Group, underwent regional metamorphism and deformation during the Avalonian (Cadomian) Orogeny (Helmstaedt and Tella, 1973).

Metavolcanic rocks intruded by the Coxheath Pluton have generally been assigned to the Fourchu Group (Keppie, 1979), and include andesite, latite, trachyte, dacite and tuffaceous rocks, together with minor sedimentary rocks (Chatterjee et al., 1980). Similar rocks, highly sheared and altered, were mapped during the present study in an area south of the Spruce Brook Pluton (Fig. 2). Previously published maps (e.g. Keppie, 1979) showed these rocks as part of the George River Group, but on the basis of lithology they seem more appropriately correlated with the Fourchu Group.

BOURINOT GROUP AND OVERLYING CAMBRO-ORDOVICIAN FORMATIONS

The main occurrence of the Bourinot Group and overlying MacMullin, MacNeil and McLeod Brook Formations extends along the northwestern margin of the Boisdale Hills Pluton, separating it from the Shunacadie Pluton to the northwest (Fig. 2). These rock units consist of Middle Cambrian to Lower Ordovician volcanic and generally shallow marine clastic sedimentary rocks, unconformably overlying the George River Group in a northeasterly trending synclinal structure (Hutchinson, 1952; Helmstaedt and Tella, 1973). In addition to the main belt, these rocks also occur in the area between the Spruce Brook and Coxheath Plutons, and in a small area west of the Spruce Brook Pluton (Fig. 2). Their stratigraphy and palaeontology were described in detail by Hutchinson (1952), and their age is well established. The rocks appear to be essentially unmetamorphosed and deformation probably took place during the Acadian Orogeny (Helmstaedt and Tella, 1973).

Contact relations between the granitoid rocks and these Cambro-Ordovician rock units are generally poorly understood due to poor exposure and/or faulting. This is exemplified by the controversy concerning the ages of the intrusive rocks as previously described. The Cambro-Ordovician rocks are inferred to be younger than the plutonic rocks on the basis of lack of observed crosscutting relations or contact metamorphic effects, combined with published radiometric age data. Furthermore, pebbles of diorite and granitic rocks have been reported in lower Middle Cambrian Bourinot Group rocks on Long Island (Helmstaedt and Tella, 1972). However, Helmstaedt and Tella (1972) also reported local contact metamorphism in the same rock units adjacent to the Spruce Brook Pluton and possibly the Boisdale Hills Pluton near Barachois Harbour, but these were not confirmed by the present study.

McADAM LAKE FORMATION

The Lower to Middle Devonian McAdam Lake Formation lies north of the Spruce Brook Pluton. It consists of conglomerate, arkose, shale and a thin band of felsic tuff (Bell and Goranson, 1938). The Formation is apparently in faulted contact with the George River Group to the north, and possibly with the Spruce Brook Pluton and Fourchu Group to the south (Keppie, 1979). No outcrops were found in the inferred contact area.

GRANTMIRE FORMATION AND WINDSOR AND CANSO GROUPS

The Lower Carboniferous Grantmire Formation nonconformably overlies the older rock units around the perimeter of the Boisdale Peninsula (Figs. 1 and 2). It consists primarily of red clastic rocks of arkosic composition.

In the northeastern part of the map area, and in the south along the shore of East Bay, limestone of the Windsor Group is present (Bell and Goranson, 1930; Giles, 1982; 1983), mostly in faulted contact with older rock units (Fig. 2). In the extreme northeast, this Windsor Group limestone is overlain by sedimentary units of the Canso Group.

SHUNACADIE PLUTON

FIELD OBSERVATIONS

The Shunacadie Pluton (Poole, 1980) consists predominantly of distinctive, relatively homogeneous, medium grained pink biotite granodiorite, with small bodies of diorite, granite and leucogranite in four marginal areas (Fig. 1). The biotite granodiorite is well exposed in Beaver Brook east of Shunacadie, which could be considered the type section for the Pluton. These plutonic rocks are overlain nonconformably by arkosic sedimentary rocks largely derived from them and assigned to the Grantmire Formation by Weeks (1954). The unconformities are locally well exposed in stream sections such as east of Benacadie Pond on the margins of the Pluton. Arkose also occurs in isolated patches within the Pluton at elevations as high as 200 m, indicating considerable topographic relief during the early Carboniferous or subsequent vertical movements due to faulting or both.

Contacts with the George River Group were not found exposed, although at several localities (shown as defined contacts on the map) outcrops of the two units are within a few metres of one another. However, small metasedimentary xenoliths with a probable George River Group source were observed in the plutonic rocks at various localities near contacts, and the relationship is undoubtedly intrusive. Mafic schist and amphibolite units northwest of the southern lobe of the Shunacadie Pluton include spotted schist with cordierite porphyroblasts which probably resulted from contact metamorphism.

Contacts with Cambro-Ordovician rocks were also not directly observed, although granite and sedimentary rocks are exposed within about five metres of one another in tributaries west of Indian Brook (Fig. 2). There the contact is inferred to be nonconformable because there is no evidence of faulting or contact metamorphism.

Relations between the main biotite granodiorite body and the more felsic marginal granitoid units are uncertain. The elongate band of granite lying along the southern margin of the granodiorite west of Steele Crossing (Fig. 2) was not observed in contact with the granodiorite. The granite is texturally similar to the granodiorite, and may be a more felsic but related (younger?) body. The two small bodies of leucogranite at the southwestern ends of both lobes of the Shunacadie Pluton (Fig. 2) are of uncertain extent. No contacts were found, but they are also presumed to be younger than the granodiorite. Granodiorite in the stream section north of the southern leucogranite body has numerous irregular aplitic dykes which may be related to the leucogranite, thus supporting the assumed relative ages. Elsewhere in the granodiorite, aplitic and pegmatitic dykes are rarely present.

The small inlier of dioritic rocks at the northern margin of the southern lobe of the Shunacadie Pluton (Fig. 2) is in sharp contact with the granodiorite. Although chilling is not apparent in the granodiorite at the contact, small dykes of granodiorite were observed in the diorite near the contact indicating that the diorite is older.

Mafic dykes are abundant in the Shunacadie Pluton; over 40 were observed in the field. These tend to be narrow (average about one metre in width) and oriented north-northeast and east-northeast (Fig. 3a), similar to major joint directions (Fig. 3b). Such dykes are apparently

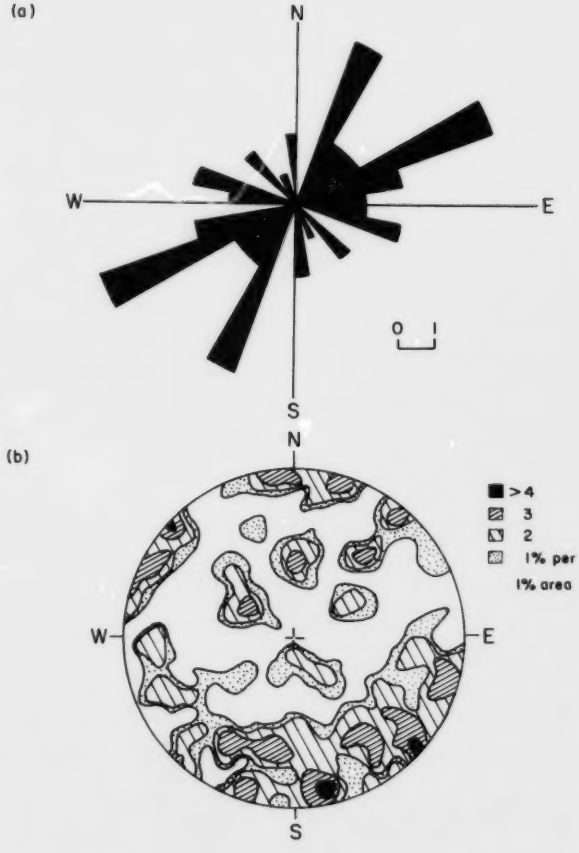

Figure 3. (a) Rose diagram showing the orientations of 32 mafic dykes in the Shunacadie Pluton. (b) Contoured plot of 125 poles to joints on a Schmidt equal area stereonet.

common in pre-Windsor Group rocks throughout Cape Breton Island, and are of uncertain age(s) and chemical affinity. They may be related to the Devonian volcanism represented in the Fisset Brook and McAdam Lake Formations (Blanchard, 1982) or to older volcanic episodes (e.g. Bourinot Group). A large felsite dyke (or series of dykes) parallels regional trends in the western part of the Shunacadie Pluton (Fig. 2), where it can be traced for about four kilometres.

Jointing is well developed in the Pluton, but patterns are somewhat diffuse (Fig. 3b). Many trend approximately northeast-southwest, with minor cross joints oriented northwest-southeast. A second major set trends approximately east-west, with dips ranging from steep to moderate, both north and south. Joint spacing is variable, but generally about 30-50 cm.

Shear zones, generally trending northeast, are common in the Shunacadie Pluton. They are marked by friable texture and grey discolouration in the normally pink granodiorite. Well exposed sections enable the observation of gradational change from normal granodiorite to altered granodiorite in shear zones. However, isolated outcrops of such altered rock are barely recognizable as originally granitoid.

PETROGRAPHY

Biotite Granodiorite

The biotite granodiorite which forms the bulk of the Shunacadie Pluton is a relatively homogeneous rock with medium grained hypidiomorphic granular texture (Fig. 4). The average modal analysis of 22 representative samples (Fig. 5) is 46 per cent plagioclase, 14 per cent microcline, 26 per cent quartz and 14 per cent biotite. Accessory minerals include apatite and zircon (mostly as inclusions in biotite), opaque minerals (magnetite) and sphene, the latter forming large (up to 2 mm) subhedral grains. With the exception of samples from near shear zones, the rocks have a moderate degree of alteration, with plagioclase partly replaced (especially in the cores) by sericite, epidote and other fine grained secondary minerals and biotite partly or wholly replaced by chlorite, epidote, sphene and opaques. Microcline is only slightly altered to sericite. Characteristic pink colouration of the feldspars in hand specimen is probably due to a fine dusting of iron oxide.

Plagioclase typically has the largest grain size in the rock. It is generally subhedral and strongly zoned from about An_{40} in cores to An_{15-30} near rims (Table 1). Outermost rims are locally albitic in composition (An_{3-5}), probably as a result of late-stage overgrowths.

Microcline is anhedral, interstitial and locally poikilitic where it partially encloses plagioclase. It displays variably developed cross-hatched twinning and twin lamellae are deformed in some samples. Perthitic exsolution lamellae are only rarely obvious. Microprobe analyses indicated compositions in the range Or_{90-98} (Table 1).

Quartz is interstitial and anhedral in form. Undulatory extinction is ubiquitous and grain boundaries are generally sutured, both features indicative of late stage or postcrystallization deformation, perhaps due to faulting.

Biotite is subhedral with scattered inclusions of zircon and apatite. Many grains are slightly crumpled or kinked, again evidence of deformation. Compositions (Table 1) are moderately high in TiO_2 (2-4 per cent) and MnO (0.5-1.0 per cent) with Fe/Fe+Mg ratios of about 0.4 to 0.5, fairly typical of rocks of granodioritic composition (Deer et al., 1966).

Granite

The granite is similar in grain size and texture to the biotite granodiorite but contains a much lower percentage of mafic minerals, including both biotite and green amphibole. It also contains more potassium feldspar (Fig. 5) which, on the basis of absence of cross-hatched twinning, may be orthoclase rather than microcline perthite (Fig. 6). Degree and type of alteration is similar to that in the biotite granodiorite.

Leucogranite

Both bodies of leucogranite in the Shunacadie Pluton consist of quartz, microcline perthite and plagioclase, with minor sericitic muscovite and rare chlorite (after biotite?) in a very coarse grained allotriomorphic granular texture (Fig. 7). Plagioclase is of albite/oligoclase composition with albite rims. Cross-hatched twinning is much better developed in the northern body, whereas the other body contains relatively larger and simply twinned microcline crystals, as well as more quartz and less plagioclase (Fig. 5).

Diorite

Athough small, the diorite body is quite varied in composition and grain size. It includes medium- and fine-grained diorite and leucodiorite, and irregular net-veined mixtures of these. Narrow pegmatoid dioritic dykes and quartz veins of varied orientation are common. Diorite samples consist mostly of plagioclase (about An_{50}) and green amphibole, with variable amounts of pyroxene and biotite, and interstitial quartz and potassium feldspar. Mafic mineral compositions from one sample, a quartz monzodiorite, are given in Table 2. In this rock, relict orthopyroxene (in places rimmed by clinopyroxene) is rimmed by amphibole, which in turn is rimmed by biotite (Fig. 8). The orthopyroxene is of hypersthene composition with fairly high TiO_2 and MnO contents. The clinopyroxene is of salite composition and Ti, Ca, Na and Al contents, when compared to criteria cited by Leterrier et al. (1982), are consistent with those in mafic rocks of calc-alkalic affinity.

The green amphibole is a magnesio- hornblende (terminology of Leake, 1978) with slightly high TiO_2 content. The biotite is very similar in composition to that in the biotite granodiorite (Table 1), but lower in Mn, possibly because the Mn is tied up in amphibole and pyroxene.

Figure 4. Typical biotite granodiorite of the Shunacadie Pluton, showing biotite (partially replaced by chlorite, left), microcline (with cross-hatched twinning), plagioclase and quartz (upper right). Sample 1512, cross polarized light.

CHEMISTRY

Biotite Granodiorite

The analyzed samples from the biotite granodiorite range from 64 to 72 per cent SiO_2. The average contents of TiO_2, $Fe_2O_3^t$, MnO, CaO and Na_2O are similar to or slightly lower than the averages for rocks of similar SiO_2 contents in other Cape Breton plutons, whereas K_2O and P_2O_5 are distinctly lower and Al_2O_3 is higher (Fig. 9). The latter differences seem to be reflected in the presence of normative corundum (average 1.9 per cent) (Fig. 10), not generally a feature of Cape Breton plutons (Barr et al., 1982). The oxides Al_2O_3, K_2O and P_2O_5, as well as CaO, show considerable variation; K_2O is especially obvious because of its unusual negative correlation with SiO_2 (R=-0.57). These variations may be in part related to alteration, because K_2O content does not correlate very well with amount of modal K-feldspar in the rock (R=0.54). No correlation is present between K_2O and amount of normative corundum (R=-0.02) although there is a weak correlation between Al_2O_3 and normative corundum (R=0.37). The significance of alteration and peraluminous character will be further discussed later in this paper.

The granodiorite has a relatively narrow range of differentiation indices from 72 to 78 (Fig. 10), appropriate to its granodioritic modal composition. Modal and normative compositions are similar (Fig. 8a, 8b).

Rubidium values in the granodiorite do not show wide variation and are somewhat lower than in equivalent granitoid rocks from other Cape Breton plutons (Fig. 11). However, both Ba and Sr display wider variation and a negative correlation with SiO_2 (Fig. 11), similar in fact to the pattern for K_2O (Fig. 9). As these elements would not normally be expected to show such a wide range within one rock type, it seems likely that secondary processes have affected their distribution. On the other hand, the ternary plot of Ba-Rb-Sr shows much less scatter (Fig. 12), suggesting comobility of Ba and Sr.

The metals copper, molybdenum, lead and zinc also display considerable variation in the granodiorite, but include no highly anomalous values (Fig. 13). In fact, average lead values are generally low compared to other Cape Breton granitoid rocks. Tin, uranium and fluorine have abundances similar to other Cape Breton granitoid rocks (Fig. 14). Tungsten is below the detection limit of 4 ppm in all analyzed samples.

Granite

The granite of the Shunacadie Pluton is much more felsic than the granodiorite, containing about 73 per cent SiO_2 (Table 3; Fig. 9). Other major element abundances are similar to those in other granitoid rocks in Cape Breton Island of similar SiO_2 contents, except somewhat lower Na_2O (Fig. 9). Like the granodiorite, the granite contains normative corundum (average 1.3 per cent) (Fig. 10).

Trace element contents generally lie close to the average line for other Cape Breton granites, with some notable exceptions including low Sr (Fig. 11), high Cu (Fig. 13), high Sn and low F (Fig. 14). With only two samples analyzed,

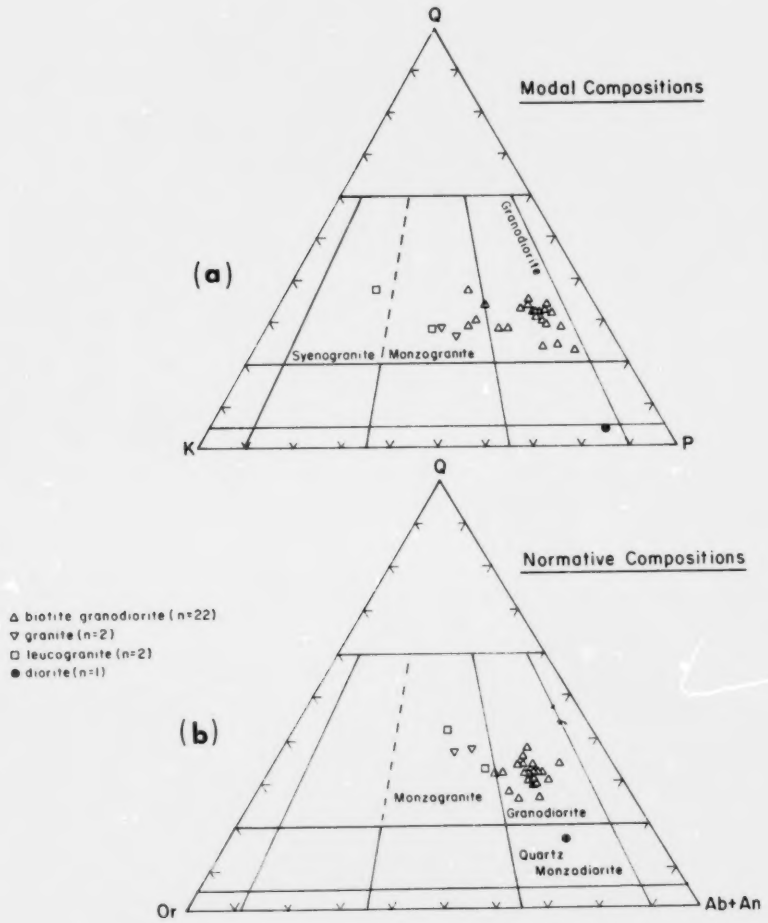

Figure 5. (a) Modal quartz-potassium feldspar-plagioclase ternary diagram for Shunacadie Pluton. Fields are from Streckeisen (1976). (b) Normative quartz-orthoclase-albite+anorthite ternary diagram for Shunacadie Pluton. Fields are from Streckeisen (1976).

the significance of these data is difficult to assess.

Leucogranite

The leucogranites are even more silicic than the granite and have major element abundances consistent with this highly evolved composition (Table 3; Fig. 9), including very low TiO_2, Fe_2O_3, MnO, MgO, CaO and P_2O_5, relatively low Al_2O_3 and Na_2O, and high K_2O. On the basis of major element trends, both the granite and the leucogranite could be evolved from the granodiorite magma, but the evidence is weak.

Like the granite, the leucogranites are low in Sr and one sample (1518) is low in Ba (Fig. 11), and hence plots as strongly differentiated on the Ba-Rb-Sr ternary diagram (Fig. 12). Other trace elements are generally similar to those in other highly silicic granitoid rocks in Cape Breton Island (Figs. 13 and 14), except for rather low F levels.

Diorite

The single analyzed sample from the diorite body is much lower in SiO_2 than the granodiorite, with corresponding differences in the other major elements (Table 3; Fig. 9). It does not contain normative corundum and has a differentiation index of 48, consistent with its dioritic composition (Fig. 10). The most anomalous feature is the high Cu content of 240 ppm (Fig. 13).

The data do not provide clear evidence as to whether or not the diorite is genetically related to the other units of the Shunacadie Pluton. Its possible relationship to dioritic rocks in the Boisdale Hills Pluton will be discussed in a later section.

AGE RELATIONS

Field evidence does not provide clear indications of the relative ages of the four lithologies of

Table 1. Typical mineral compositions in biotite granodiorite of the Shunacadie Pluton.

	PLAGIOCLASE							MICROCLINE		BIOTITE			
	1505		1512		1549			1512	1549	1505		1512	1549
	Core	Rim	Core	Rim	Core	Rim	Overgrowth						
SiO_2	58.06	63.45	59.50	63.86	56.47	61.01	66.65	63.93	64.17		37.42	38.32	37.20
TiO_2	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00		2.66	1.80	3.55
Al_2O_3	26.65	23.27	24.78	22.41	27.16	24.26	20.42	17.92	18.16		15.12	16.21	14.88
FeO	0.13	0.20	0.30	0.11	0.12	0.17	0.06	0.12	0.12		19.86	18.81	19.06
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.74	0.47	0.78
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		11.55	12.33	11.57
CaO	8.55	4.38	6.74	3.40	9.03	5.91	0.76	0.00	0.00		0.00	0.00	0.00
Na_2O	6.95	9.20	7.88	9.57	6.24	8.17	11.05	0.82	0.81		0.00	0.00	0.00
K_2O	0.21	0.30	0.27	0.09	0.10	0.32	0.29	15.31	15.45		9.45	9.24	8.90
TOTAL	100.39	100.74	99.45	99.44	99.07	99.77	99.23	98.10	98.80		96.86	97.18	95.94
Cations	O=32	O=32	O=32	O=32	O=32	O=32	O=32	O=32	O=32		O=24	O=24	O=24
Si	10.35	11.16	10.67	11.33	10.22	10.87	11.77	12.02	11.99		5.63	5.68	5.62
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		2.37	2.32	2.38
Al	5.60	4.82	5.24	4.68	5.79	5.09	4.25	3.97	4.00		0.33	0.51	0.27
Ti	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00		0.30	0.20	0.40
Fe	0.02	0.03	0.05	0.02	0.02	0.03	0.01	0.02	0.02		2.50	2.33	2.41
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.09	0.06	0.10
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		2.59	2.72	2.61
Ca	1.63	0.83	1.30	0.65	1.75	1.13	0.14	0.00	0.00		0.00	0.00	0.00
Na	2.40	3.14	2.74	3.29	2.19	2.82	3.78	0.30	0.29		0.00	0.00	0.00
K	0.05	0.07	0.06	0.02	0.02	0.07	0.07	3.67	3.68		1.81	1.75	1.72
H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		4.00	4.00	4.00
Or	1.17	1.67	1.51	0.51	0.58	1.81	1.64	92.47	92.62	Phlogopite	49.97	53.26	50.95
Ab	58.83	77.85	66.88	83.16	55.24	70.15	94.76	7.53	7.38	Annite	48.21	45.59	47.10
An	40.00	20.48	31.61	16.33	44.18	28.04	3.60	0.00	0.00	Mn-biotite	1.82	1.15	1.95
										Fe/Fe+Mg	0.50	0.47	0.49

the Shunacadie Pluton. However, the sequence diorite, biotite granodiorite, granite and leucogranite is consistent with petrographic and chemical data, and seems most likely.

Poole (1980) reported an age of 574 ± 11 Ma based on a whole-rock Rb/Sr isochron using three samples from the biotite granodiorite and two from the granite, all collected on the Bourinot Road. This indicates that there was no appreciable time gap between intrusion of these two bodies and is consistent with the late Hadrynian to early Cambrian age inferred from crosscutting relations with the Hadrynian George River Group and probable nonconformable relationships with the middle Cambrian Bourinot Group. However, mineral separates collected from the granite, apparently in the same area on the Bourinot Road, gave Rb/Sr ages of 460 and 476 Ma on biotite and K-feldspar, respectively, and a K/Ar age of 527 Ma on biotite (Fairbairn et al., 1960). The significance of these younger ages is not clear, but it is unlikely that they reflect the actual age of crystallization. Poole (1980) interpreted the Ordovician ages to represent the time of uplift of the intrusions, consistent with the lack of Ordovician sedimentary rocks in the region and with regional tectonic events (Taconian Orogeny).

BOISDALE HILLS PLUTON

FIELD OBSERVATIONS

Introduction

The Boisdale Hills Pluton (Poole, 1980) includes a variety of rock types which are here grouped into seven map units (Fig. 2). Along most of its northern edge it is in faulted contact with Cambro-Ordovician sedimentary and volcanic rocks of the Bourinot Group and overlying formations. The fault scarp is marked by a major topographic lineament which partly controls the drainage patterns of Indian and McLeod Brooks. Along much of their southern margin the plutonic rocks intrude rocks of the George River Group. Locally in the northeast and southwest they are nonconformably overlain by, or in faulted contact with, Carboniferous sedimentary rocks of the Grantmire Formation and Windsor Group.

Age relations among the seven granitoid map units are not completely known, but field relations of the units are described below in an inferred intrusive sequence. In addition to these map units, small irregular bodies of white leucocratic granite were observed within the George River metasedimentary rocks west of Eskasoni. Their relationship, if any, to the granitoid units described below is not known.

Mafic dykes are abundant in all map units. The most common orientation is northeast-southwest (Fig. 15a) parallel to a major joint direction and regional structural grain.

Three main sets of joints are developed in the plutonic rocks (Fig. 15b) in more or less the same directions observed in the Shunacadie Pluton (Fig. 3b). Maxima are better demonstrated for the Boisdale Hills Pluton, probably because of a much larger number of measurements, at about 040-045°, 130° and 080°. A less prominent fourth set which was not obvious in the Shunacadie data is developed in an approximately north-south direction. Joint spacing is variable, but generally between 0.2 m and 2 m, with local occurrences of more highly fractured rocks with smaller joint spacing.

These joint sets are also present in the George River Group adjacent to the Pluton, but do not appear to be developed in the rocks of the Bourinot Group and younger units. Hence their development may have resulted from stresses related to the Cadomian Orogeny and subsequent deformation prior to the middle Cambrian.

As in the Shunacadie Pluton, shearing and faulting are widely developed in the Boisdale Hills Pluton, accompanied by variably intense alteration and cataclasis of the granitoid rocks. Cataclastic effects are locally strong adjacent to the Indian Brook-McLeod Brook Fault along the northwestern margin of the Pluton.

Dioritic Rocks

Dioritic rocks in the central part of the area apparently occur along the Indian Brook Fault (Fig. 2). However, outcrop is limited and actual distribution of diorite is not well defined. The diorites in this central area are varied in grain size with the finer grained rocks generally more melanocratic in appearance. In most places the rocks are brecciated and veined by more leucocratic material, probably related to the granodiorite to the east, an assumption supported by observations in a briefly exposed septic tank excavation at Steele Crossing where medium- and fine-grained diorite were observed to have been brecciated by granodiorite. These relationships were clearer than in outcrops closer to the fault scarp where the rocks are intensely sheared.

Similar relationships and variations were observed in dioritic outcrops to the northeast. In the George Lake area, the rocks are predominantly fine grained diorite (microdiorite). The dioritic belt then appears to gradually die out to the northeast where it forms isolated outcrops (in some cases difficult to distinguish from mafic dykes) between the leucogranite and the George River Group (Fig. 2). Many features of the dioritic rocks are well displayed in roadside outcrops north of MacAulays Lakes.

Hornblende Granodiorite

Hornblende granodiorite forms a large body southwest of Eskasoni (Fig. 2). This body was not mapped in detail, but where observed (in three sections) consists of distinctive, very coarse grained altered rock, variable in colour from white to red. Although more leucocratic, it is similar in appearance to some of the coarse grained dioritic rocks adjacent to Indian Brook near Eskasoni. Roadside outcrops west of Eskasoni are typical of the unit. It is highly sheared and fractured in most outcrops. It contains abundant large mafic metavolcanic(?) and metasedimentary xenoliths, inferred to originate from the George River Group.

Figure 6. Granite of the Shunacadie Pluton, containing orthoclase (on left), plagioclase (with deformed twinning), shattered quartz and minor chloritized biotite. Sample 1583, cross polarized light.

In a brook near its western margin, the hornblende granodiorite appears to have intruded a gneissic rock containing thin red granitoid bands. This is interpreted to be a migmatitic zone in George River Group rocks, but it is not clear whether it is of contact or regional metamorphic origin. Gneissic rocks were also observed in Christmas Brook near Eskasoni, in a narrow band of the George River Group between the hornblende granodiorite and biotite granodiorite of the Shunacadie Pluton (Fig. 2). Contacts with the Bourinot Group were not observed because outcrop is limited in the relevant areas.

Biotite Hornblende Granodiorite

The biotite hornblende granodiorite is the most extensive map unit in the Boisdale Hills Pluton. In outcrop it is somewhat similar to the Shunacadie granodiorite, but it contains abundant amphibole as well as biotite whereas the Shunacadie granodiorite (and biotite granodiorite of the Boisdale Hills Pluton, see below) generally contains only biotite.

Exposure in much of the area of the biotite hornblende granodiorite is poor, but the unit appears to be quite homogeneous. It intruded the dioritic rocks previously described and is intruded by biotite granodiorite along part of its eastern margin; the latter contact is exposed in the road section between Barachois Harbour and Leitches Creek. Typical outcrops of the biotite hornblende granodiorite occur in road and stream sections southwest of MacAulays Lakes.

Biotite Granodiorite

Biotite granodiorite forms a major body along the southeastern margin of the Boisdale Hills Pluton between Steele Crossing and Mount Cameron (Fig. 2). The medium grained equigranular texture, red colour in outcrop and general lack of amphibole are features similar to those of the Shunacadie granodiorite already described, and these two units may be equivalent. However, as described by Setter (1981), the biotite granodiorite of the Boisdale Hills Pluton is much less homogeneous than the Shunacadie granodiorite, particularly in mafic mineral content. It appears to increase in mafic mineral content from the centre towards its contacts with other granitoid units and with the country rocks. However, limited outcrop distribution made it impossible to quantify these observations. Best exposures occur along the road section south of MacAulays Lakes.

Syenogranite

The syenogranite is a distinctive, fine grained, red to pink rock which has been previously referred to as syenite (Cormier, 1972) or alaskite (Setter, 1981). It occurs in the vicinity of Mount Cameron at the northern end of the Boisdale Hills Pluton and is well exposed in a quarry south of Long Island. Its western margin is a faulted contact with the Bourinot Group and related formations. Along its eastern margin it lies in faulted contact with the Windsor Group in the north and elsewhere in inferred intrusive contact with the George River Group or other granitoid rocks. A large dyke of

Figure 7. Leucogranites of the Shunacadie Pluton (a) microcline, plagioclase (with albitic rims), quartz and minor secondary muscovite in Sample 1518, cross polarized light, (b) microcline(?), plagioclase and quartz in Sample 1547, cross polarized light.

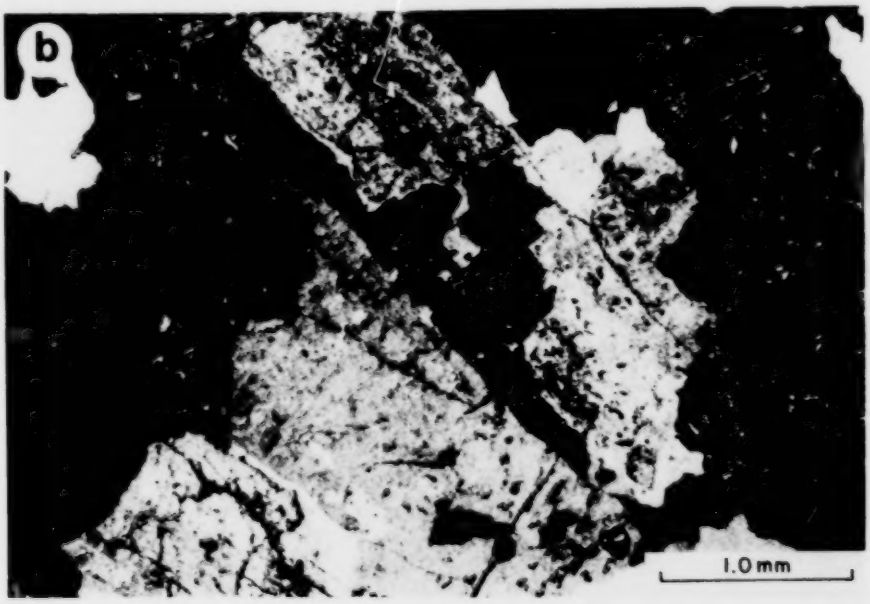

Table 2. Typical mafic mineral analyses from diorite sample 1570, Shunacadie Pluton

	Orthopyroxene	Clinopyroxene	Amphibole	Biotite
SiO_2	51.58	51.39	47.90	37.10
TiO_2	0.16	0.44	0.56	2.91
Al_2O_3	1.27	2.14	7.00	14.45
FeO	25.20	10.03	16.38	19.38
MnO	0.90	0.51	0.39	0.07
MgO	19.50	12.45	12.99	12.43
CaO	1.36	21.93	11.29	0.00
Na_2O	0.00	0.17	0.67	0.00
K_2O	0.00	0.00	0.59	9.19
Total	99.97	99.06	97.77	95.53
Cations	O=6	O=6	O=24	O=24
Si	1.96	1.95	7.08	5.64
Al	0.04	0.05	0.92	2.36
Al	0.02	0.04	0.30	0.23
Ti	0.01	0.01	0.06	0.33
Fe	0.80	0.32	2.03	2.46
Mn	0.03	0.02	0.05	0.01
Mg	1.10	0.70	2.86	2.82
Ca	0.06	0.89	1.79	0.00
Na	0.00	0.01	0.19	0.00
K	0.00	0.00	0.11	1.78
H	0.00	0.00	2.00	4.00
Wo	2.82	46.58		
En	56.33	36.79		
Fs	40.84	16.63		
Fe/Fe+Mg	0.42	0.31	0.42	0.47

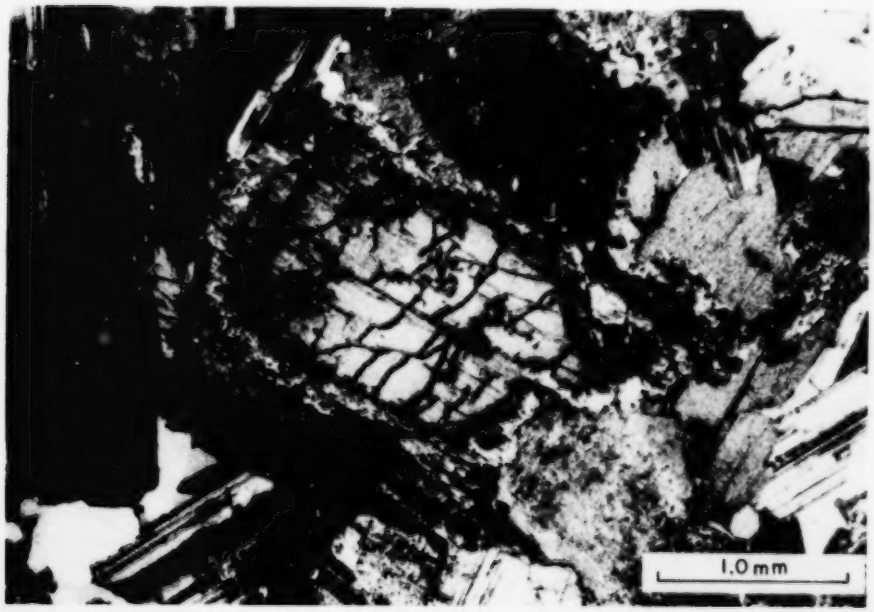

Figure 8. Quartz diorite of the Shunacadie Pluton, showing relict pyroxene rimmed by amphibole and biotite. Sample 1570, cross polarized light.

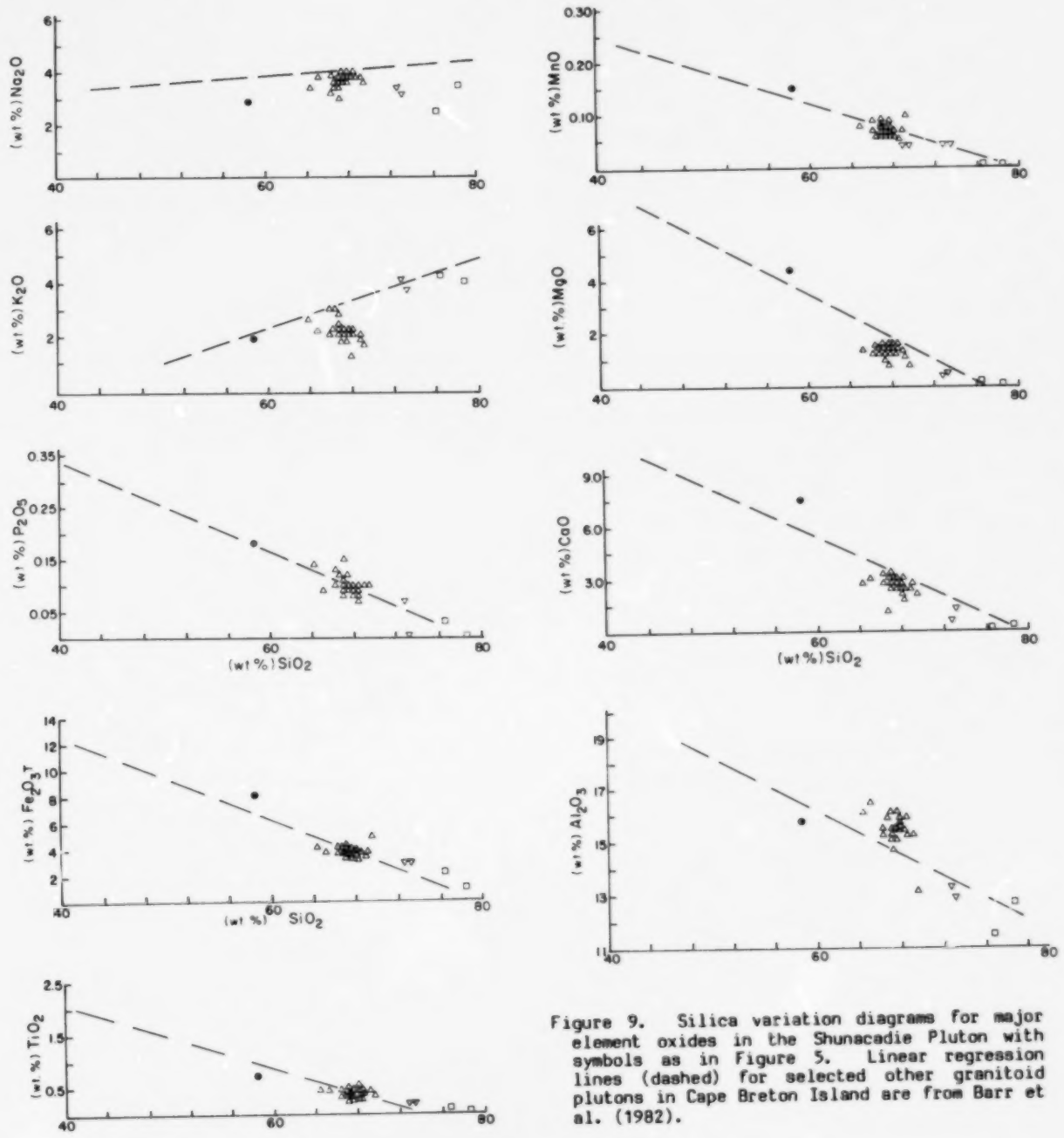

Figure 9. Silica variation diagrams for major element oxides in the Shunacadie Pluton with symbols as in Figure 5. Linear regression lines (dashed) for selected other granitoid plutons in Cape Breton Island are from Barr et al. (1982).

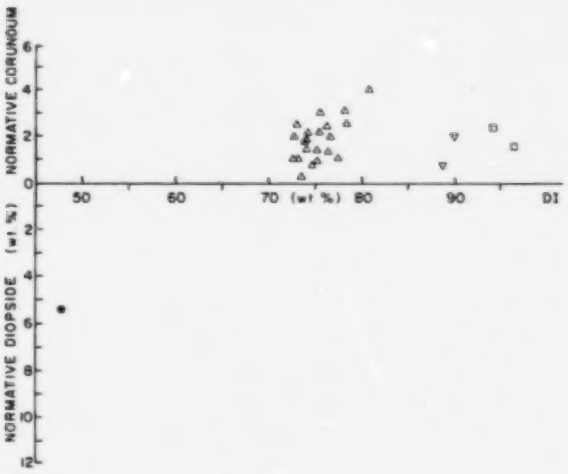

Figure 10. Plot of normative corundum or diopside against differentiation index (Thornton and Tuttle, 1960) for Shunacadie Pluton, with symbols as in Figure 5.

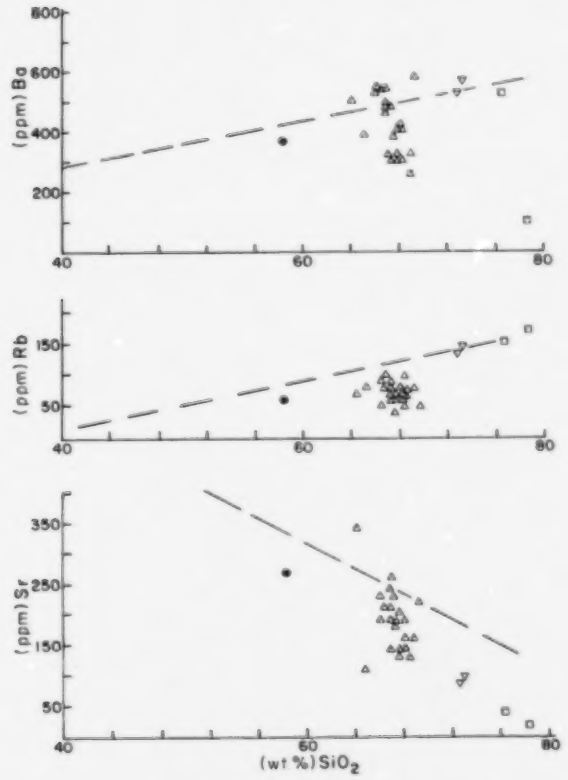

Figure 11. Silica variation diagrams for Ba, Rb and Sr in Shunacadie Pluton with symbols and lines as in Figures 5 and 9.

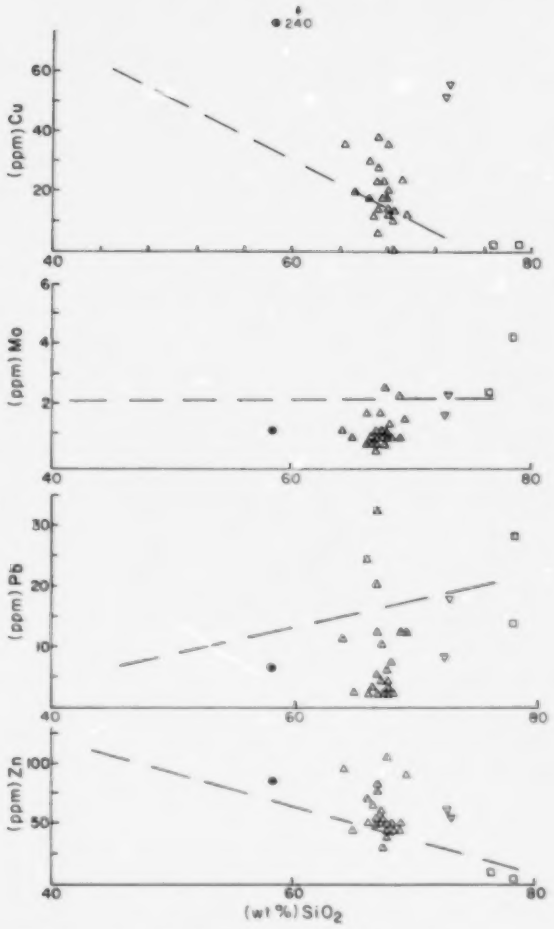

Figure 12. Ternary plot of Ba-Rb-Sr for Shunacadie Pluton, with symbols as in Figure 5. Fields are from El Bouseily and El Sokkary (1975).

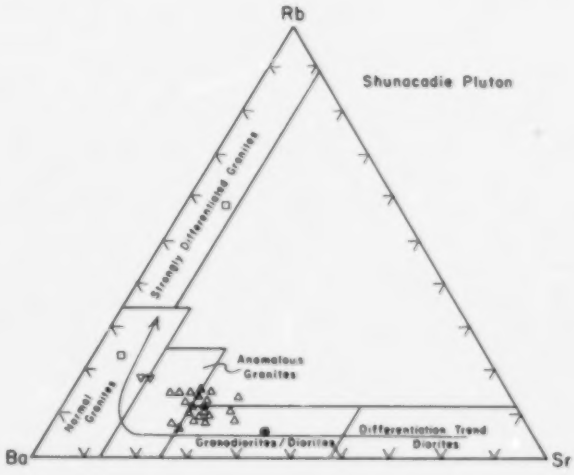

Figure 13. Silica variation diagrams for Cu, Mo, Pb and Zn in Shunacadie Pluton with symbols and lines as in Figures 5 and 9.

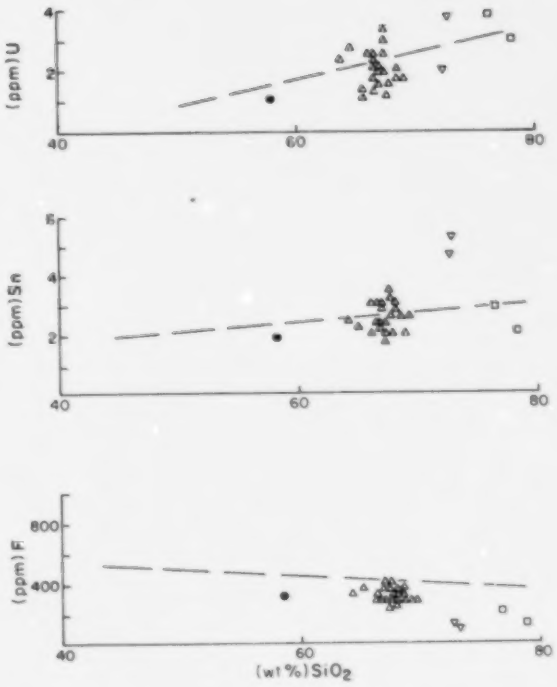

Figure 14. Silica variation diagrams for U, Sn and F in Shunacadie Pluton with symbols and lines as in Figures 5 and 9.

apparently the same lithology cuts the biotite granodiorite of the Boisdale Hills Pluton at its contact with the George River Group near Frenchvale (Fig. 2), indirect evidence of relative ages of the syenogranite and the granodiorite.

No xenoliths or granitoid dykes were observed in the syenogranite. The absence of dykes is evidence for the inferred position of the syenogranite, late in the intrusive sequence.

Microgranite

A band of heterogeneous fine grained granite (leucotonalite of Setter, 1981) lies within predominantly dioritic rocks northwest of MacAulays Lakes. In places, abundant syenogranite-like veinlets occur in dioritic rocks; in other places, the rock looks similar to the Mount Cameron syenogranite body. Some samples resemble fine grained diorite, but contain abundant potassium feldspar. The unit appears to be a hybrid formed by intrusion of syenogranite magma into microdioritic and dioritic rocks.

Leucogranite

A body of medium- to coarse-grained pink leucogranite occurs on the western margin of the biotite hornblende granodiorite north of Steele Crossing (Fig. 2). Like other units, these rocks are highly sheared along their faulted northern margin and locally appear aphanitic. They contain essentially no mafic minerals and are very similar to leucogranites previously described in the Shunacadie Pluton to the south.

Table 3. Means and standard deviations of analyses from the Shunacadie Pluton.

	Biotite Granodiorite n = 22	Granite n = 2	Leucogranite n = 2	Diorite (#1570) n = 1
SiO_2	67.5 ± 1.2	73.0 ± 0.1	77.3 ± 1.4	58.6
TiO_2	0.49 ± 0.05	0.29 ± 0.00	0.12 ± 0.11	0.77
Al_2O_3	15.5 ± 0.7	13.1 ± 0.3	12.0 ± 0.9	15.8
Fe_2O_3	3.9 ± 0.4	3.2 ± 0.5	1.0 ± 0.4	8.2
MnO	0.09 ± 0.01	0.05 ± 0.0	0.01 ± 0.0	0.16
MgO	1.5 ± 0.2	0.5 ± 0.1	0.1 ± 0.1	4.5
CaO	2.8 ± 0.5	1.0 ± 0.4	0.3 ± 0.1	7.2
Na_2O	3.7 ± 0.3	3.3 ± 0.1	3.0 ± 0.7	2.8
K_2O	2.5 ± 0.5	4.2 ± 0.2	4.4 ± 0.1	2.1
P_2O_5	0.11 ± 0.02	0.08 ± 0.01	0.03 ± 0.02	0.19
Ba	433 ± 95	540 ± 28	321 ± 303	370
Cu	20 ± 10	6 ± 1	2 ± 0	240
F	320 ± 40	450 ± 85	190 ± 71	300
Mo	1.3 ± 0.5	2.1 ± 0.2	3.1 ± 1.8	1.4
Pb	8 ± 8	13 ± 7	20 ± 11	6
Rb	76 ± 16	149 ± 9	175 ± 10	68
Sn	2.7 ± 0.5	5.1 ± 0.4	2.6 ± 0.6	2.2
Sr	197 ± 51	96 ± 6	34 ± 13	275
U	2.3 ± 0.6	3.4 ± 1.0	3.6 ± 0.6	1.2
W	<4	<4	<4	<4
Zn	62 ± 20	58 ± 4	8 ± 4	86

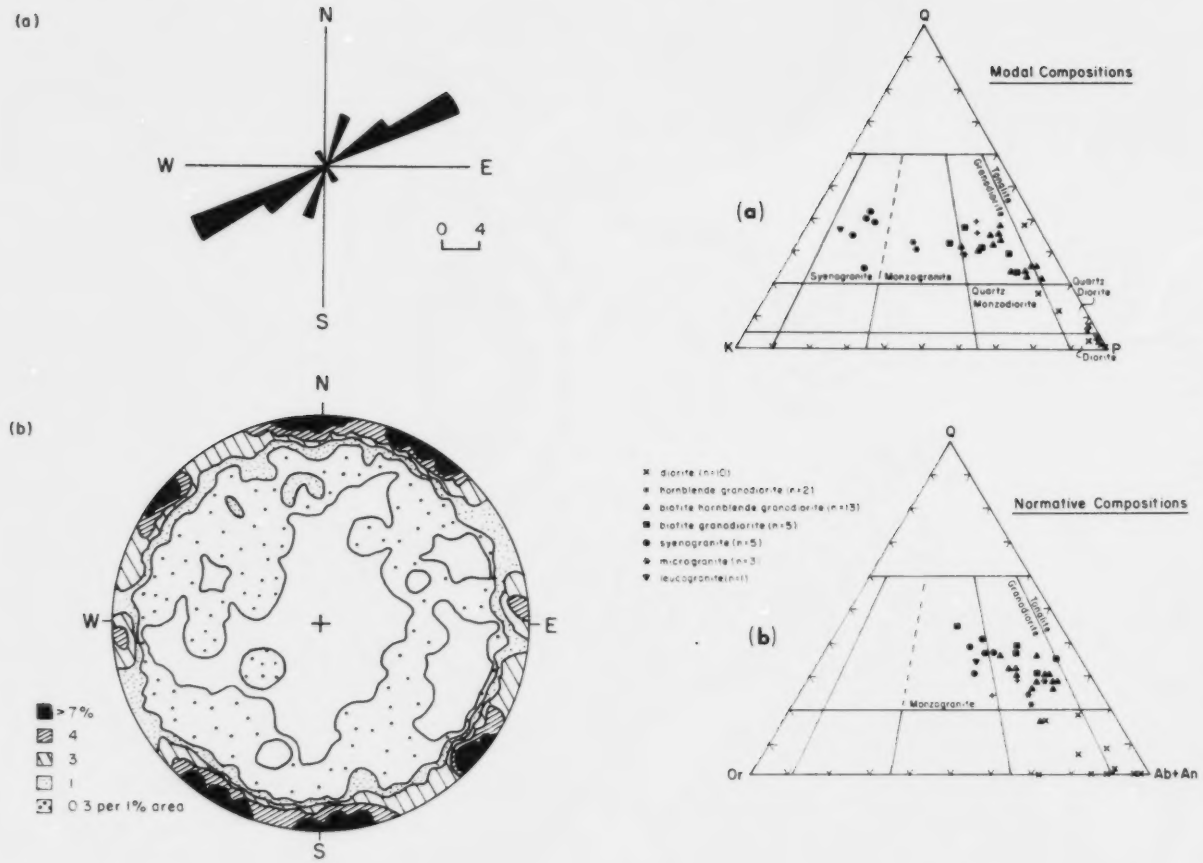

Figure 15. (a) Rose diagram showing the orientations of 32 mafic dykes in the Boisdale Hills Pluton. (b) Contoured plot of 311 poles to joints on a Schmidt equal area stereonet. Contours at more than 0.3, 1, 3, 4 and 7% per 1% area.

Figure 16. (a) Modal quartz-potassium feldspar-plagioclase ternary diagram for Boisdale Hills Pluton. Fields are from Streckeisen (1976). (b) Normative quartz-orthoclase-albite+ anorthite ternary diagram for Boisdale Hills Pluton. Fields are from Streckeisen (1976).

PETROGRAPHY

Dioritic Rocks

The dioritic rocks vary from diorite to tonalite, as exemplified by the ten, more or less typical, samples selected for chemical analyses (Fig. 16a). They show wide variation in grain size, texture and mafic mineral abundance and hence are difficult to characterize in general terms. Similar variations have been observed in dioritic parts of other plutons of similar age in Cape Breton Island, and have been attributed to fractional crystallization processes complicated by later intrusive events (Barr et al., 1982).

Subhedral plagioclase of composition An_{40-60} is typically the most abundant mineral. Zoning is not well developed. The grains are altered to varying degrees to mixtures of sericite, saussurite, albite and various other fine grained products (Fig. 17).

Mafic minerals, generally forming 30 to 50 per cent of the rocks, include amphibole, biotite and, rarely, pyroxene. The amphibole is pleochroic in shades of green and brown and is strongly zoned (Table 4), with marked increase in TiO_2, Al_2O_3, MgO and Na_2O and decrease in SiO_2, FeO[T] and K_2O from core to rim. Amphibole rims on clinopyroxene are compositionally similar to rims on amphibole. The amphiboles are classified as magnesio-hornblende (terminology of Leake, 1978). Pleochroic brown biotite is much less abundant than hornblende and occurs both as separate flakes and in association with hornblende. It is commonly extensively altered to chlorite and hence good analyses could not be obtained. Pyroxene occurs only as relict cores within amphibole and is of salite composition (Table 4).

Opaque minerals (magnetite and/or ilmenite and in some cases pyrite) are abundant (up to 2 to 3 per cent) and generally occur in association

Figure 17. Diorite of the Boisdale Hills Pluton, showing amphibole with relict pyroxene cores, saussuritized plagioclase and minor interstitial quartz. Sample 1436, cross polarized light.

with the ferromagnesian minerals as large subhedral grains.

Quartz and alkali feldspar, where present, are anhedral and interstitial. Some of the more felsic microdiorites (e.g. sample 1215) contain up to 25 per cent quartz, but still only minor potassium feldspar.

Hornblende Granodiorite

The hornblende granodiorite has medium grained hypidiomorphic inequigranular texture dominated by large crystals of amphibole and plagioclase. The average modal composition of two samples selected for chemical analyses is 39 per cent plagioclase, 32 per cent quartz, 14 per cent K-feldspar, 10 per cent amphibole and 5 per cent biotite. The amphibole is pleochroic in shades of green, very similar to that in the biotite hornblende granodiorite (described below) which is a magnesio-hornblende. Crystals are large (up to 1 cm) and display well developed twinning. Pleochroic brown biotite is also present but much less abundant than the hornblende. It occurs as large flakes, not particularly in association with the amphibole. Both amphibole and biotite are partly altered to chlorite, epidote and hematite.

Plagioclase generally occurs as subhedral laths which are extensively altered to sericite, epidote and other fine grained secondary minerals. Quartz occurs as anhedral interstitial grains. Microcline is much less abundant, but is also interstitial and poikilitic in places, enclosing plagioclase laths (Fig. 18). Accessory minerals include apatite, zircon (as inclusions in biotite) and scattered opaques.

Biotite Hornblende Granodiorite

The biotite hornblende granodiorite has medium grained hypidiomorphic inequigranular texture. The average modal composition of 13 samples (Fig. 16a) selected for chemical analyses is 47 per cent plagioclase, 24 per cent quartz, 10 per cent microcline, 10 per cent amphibole and 9 per cent biotite, with abundant accessory opaque minerals, sphene, apatite and zircon.

Plagioclase occurs as subhedral crystals of fine to medium grain size; small grains tend to be enclosed in poikilitic amphibole, biotite, microcline or even quartz crystals (Fig. 19) showing that plagioclase was essentially the first mineral to begin crystallizing. Plagioclase is zoned, with compositions in the range An_{35} to An_{55} (e.g. Table 5). Alteration to sericite and other fine grained minerals is moderately intense (Fig. 19). Quartz and microcline are anhedral and interstitial, and vary in relative abundance (Fig. 16b).

Amphibole is generally the more abundant ferromagnesian mineral and forms large poikilitic grains which range from anhedral to subhedral. Pleochroism is in shades of green and twinning is common. Compositions (Table 5) plot in the magnesio-hornblende field of Leake (1978), but the crystals are not as strongly zoned as the magnesio-hornblendes in the diorite previously described and there is little change in composition from core to rim. The sodium content is relatively high and the composition is close to edenite. TiO_2 and Al_2O_3 contents are also high, compensated by low SiO_2. Patchy alteration to chlorite is common. Biotite occurs in large anhedral grains, both separately and in

Table 4. Typical mafic mineral analyses from diorite sample 1436, Boisdale Hills Pluton.

	Clino-pyroxene	Amphibole		
		Core	Rim	Rim on CPX
SiO_2	52.11	45.64	43.66	42.78
TiO_2	0.25	2.63	3.71	3.99
Al_2O_3	0.63	8.09	10.10	9.90
FeO	9.68	14.53	13.65	13.29
MnO	0.68	0.19	0.24	0.48
MgO	14.72	12.81	13.11	13.77
CaO	21.28	10.81	10.78	10.74
Na_2O	0.25	2.17	2.94	3.74
K_2O	0.00	0.55	0.36	0.00
Total	99.60	97.42	98.55	98.69
Cations	O=6	O=24	O=24	O=24
Si	1.96	6.77	6.42	6.57
Al	0.03	1.23	1.59	1.43
Al	0.00	0.19	0.16	0.36
Ti	0.01	0.29	0.41	0.46
Fe	0.30	1.80	1.68	1.71
Mn	0.02	0.02	0.03	0.06
Mg	0.83	2.83	2.87	3.15
Ca	0.86	1.72	1.70	1.76
Na	0.02	0.62	0.84	1.11
K	0.00	0.10	0.07	0.00
H	0.00	2.00	2.00	2.00
Wo	43.86			
En	42.20			
Fs	13.94			
Fe/Fe+Mg	0.27	0.39	0.37	0.35

association with amphibole. Compositions (Table 5) are similar to those in the Shunacadie granodiorite (Table 1), but higher in Ti and lower in Mn.

Inclusions of apatite are very abundant in biotite and amphibole. Zircon inclusions are much less common. Sphene forms separate subhedral grains which are smaller and less abundant than those in the Shunacadie biotite granodiorite.

Biotite Granodiorite

The biotite granodiorite is petrographically similar to the biotite granodiorite of the Shunacadie Pluton described previously, but apparently more varied in composition. Texture is generally medium grained hypidiomorphic to allotriomorphic inequigranular; the major minerals are plagioclase, perthitic microcline, quartz, biotite and locally amphibole (Fig. 20).

Plagioclase is typically subhedral and strongly zoned, with compositions ranging from about An_{20} to An_{45}. Sericitization is moderate to strong, especially in the cores of grains. Much of the plagioclase is partially enclosed by larger microcline and quartz. Microcline is interstitial and anhedral. Locally it is subporphyritic and poikilitic, enclosing mostly plagioclase. Fine perthitic exsolution lamellae are obvious in most grains (Fig. 20). Quartz is also interstitial and anhedral, forming granular masses with sutured grain boundaries. Undulatory extinction is prominent.

Biotite occurs in subhedral to anhedral plates with brown to pale yellow pleochroism. Compositions (Table 6) are similar to those in the biotite hornblende granodiorite (Table 5), but with higher Al and Mn, the latter similar to Mn in biotites of the biotite granodiorite of the Shunacadie Pluton (Table 1). Partial or complete replacement by chlorite is almost ubiquitous. Other alteration products are epidote and sphene. Minor pleochroic green amphibole is present in some samples.

Accessory minerals include apatite and rare zircon, mostly as inclusions in biotite, and scattered granular opaques. Separate grains of sphene like those in the Shunacadie biotite granodiorite were not observed.

Syenogranite

The syenogranite is a distinctive pink to red rock with a typically subporphyritic aphanitic appearance in hand specimen. It consists of scattered plagioclase and quartz microphenocrysts in a granophyric groundmass (Fig. 21). Chlorite, epidote and opaques are present in only minor amounts (less than 2 per cent). On the basis of form the chlorite appears to have replaced biotite but the epidote is interstitial and may be hydrothermal in origin, not a replacement mineral.

Plagioclase forms subhedral microphenocrysts of albitic composition (Table 7). Many grains have kinked twin lamellae. Alteration to sericite is relatively minor, perhaps because of the albitic composition. Quartz occurs both in scattered microphenocrysts and in granophyre. The microphenocrysts display undulatory extinction and deformation lamellae. The granophyre which makes up most of the rock is quite coarse, generally cuneiform in development (Fig. 21) and consists of perthitic microcline and quartz.

Microgranite

The microgranite has a distinctive range of textures which clearly suggest its hybrid affiliation with diorite, syenogranite and possibly the leucogranite to the south, as described previously under field observations. Grain size varies from fine to medium. The most prominent mineral is anhedral to subhedral plagioclase of zoned albitic composition with nearly pure albite rims. In some samples these rims are mantled by lacy rims of perthite (Fig. 22).

Microcline occurs both in these rims on plagioclase and as separate anhedral grains. It is finely to coarsely perthitic. In most samples, microcline also occurs in interstitial granophyre forming up to 15 per cent of the rock. Quartz occurs in the granophyre as interstitial grains and, rarely, in larger subporphyritic grains. In some samples (proximal to faults?) the quartz is highly deformed.

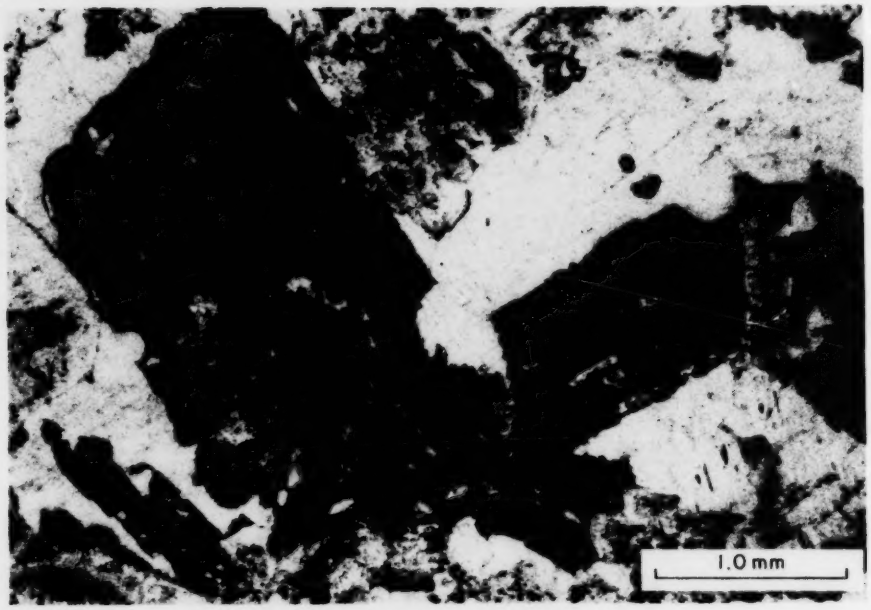

Figure 18. Hornblende granodiorite of the Boisdale Hills Pluton, containing abundant amphibole, partially saussuritized plagioclase, (in upper centre of photograph), quartz, microcline (lower left) and partially chloritized biotite. Sample 1537, plane polarized light.

Figure 19. Typical biotite hornblende granodiorite of the Boisdale Hills Pluton showing abundant amphibole (upper left and centre), biotite (upper and lower right), plagioclase (saussuritized) and quartz. Sample 1543, plane polarized light.

Table 5. Typical mineral compositions in biotite hornblende granodiorite sample 1543, Boisdale Hills Pluton.

	Plagioclase		Amphibole	Biotite
	Core	Rim		
SiO_2	54.66	58.38	45.14	36.47
TiO_2	0.00	0.00	1.39	3.48
Al_2O_3	28.54	26.57	7.85	14.87
FeO	0.10	0.19	17.78	20.10
MnO	0.00	0.00	0.53	0.19
MgO	0.00	0.00	10.78	11.07
CaO	11.13	8.42	11.01	0.00
Na_2O	5.20	6.73	1.28	0.00
K_2O	0.06	0.20	0.92	9.79
Total	99.69	100.49	96.68	95.97
Cations	O=32	O=32	O=24	O=24
Si	9.89	10.40	6.86	5.57
Al	0.00	0.00	1.14	2.45
Al	6.09	5.58	0.27	0.24
Ti	0.00	0.00	0.16	0.40
Fe	0.02	0.03	2.44	2.57
Mn	0.00	0.00	2.26	0.03
Mg	0.00	0.00	0.07	2.52
Ca	2.16	1.61	1.79	0.00
Na	1.82	2.33	0.38	0.00
K	0.01	0.05	0.18	1.91
H	0.00	0.00	2.00	4.00
Or	0.35	1.14		
Ab	45.65	58.45		
An	54.00	40.41		
Fe/Fe+Mg			0.49	0.51

Mafic minerals vary from 1 or 2 per cent to about 15 per cent. Epidote occurs both in granular masses replacing biotite and amphibole(?) in association with chlorite, and as separate angular anhedra inferred to be of primary hydrothermal origin. Opaques form scattered anhedral grains as well as finer grains associated with altered mafics. Rounded microdiorite xenoliths are present locally.

Leucogranite

In hand specimen and thin section the leucogranite is similar to those already described with the Shunacadie Pluton but contains even more potassium feldspar and hence plots in the syenogranite field (Fig. 16a). It consists of perthite, quartz and albitic plagioclase with sparse mafic minerals. Texture is medium grained allotriomorphic inequigranular (Fig. 23).

Perthite is the dominant mineral. It is anhedral and probably microcline. Several exsolution types are displayed, including plume, braid and string (Spry, 1974). Quartz is interstitial to the perthite and in places the relationship is granophyric. It is highly strained with extensive development of subgrain boundaries. Plagioclase is present in minor amounts, and forms subhedral grains enclosed in poikilitic perthite. Composition is An_{4-5} (Table 7). Mafic minerals include scattered chlorite (after biotite?), epidote and opaques.

CHEMISTRY

Dioritic Rocks

Many of the analyzed dioritic rocks are quite mafic in composition, ranging from about 45 to 58 per cent SiO_2, with a mean of only 52 per cent (Table 8), although this reflects to some extent a sampling bias towards the more mafic lithologies of the suite. The range in SiO_2 is accompanied by more or less normal variations in the other elements, although there is generally wide scatter (Fig. 24). Similar scatter in chemical compositions of dioritic rocks is apparently typical of Cape Breton granitoid suites (Barr et al., 1982). A weak to good negative correlation with SiO_2 is displayed by TiO_2, Al_2O_3, $Fe_2O_3^T$, MnO, MgO, CaO and P_2O_5 whereas K_2O has a positive correlation and Na_2O essentially no change (Fig. 24). Sample 1043, which has the lowest SiO_2 content of the analyzed rocks, is highly altered and this may account for its very low P_2O_5, K_2O and Na_2O, and high CaO.

Trace elements are also quite scattered. However, there is a reasonable positive correlation between SiO_2 and Ba as well as SiO_2 and Rb, with the exception of the altered sample 1043 which has high Ba and Rb (Fig. 25) in correspondence with high K_2O. Sr has little correlation with SiO_2, even excluding altered sample 1043 which is especially low in Sr. The anomalous Ba, Rb and Sr values in the latter sample are clear on the ternary plot (Fig. 26).

The metals Pb and Zn have reasonable positive correlation with SiO_2 (Fig. 27), normal for Pb but unusual for Zn (e.g. Gribble, 1969; Barr et al., 1982). Both Pb and Cu are low compared to other Cape Breton dioritic rocks and Mo values are low to average (Fig. 27). All of these elements have rather wide ranges, but comparison with other dioritic rocks suggests that none of the values are anomalous (Barr et al., 1982).

Uranium values are generally low, although one sample has unusually high U (Fig. 28). This same sample and one other also have high Sn levels, but most Sn values, as well as F, are more or less average (Fig. 28). One sample (1083) has 20 ppm W, but all of the others are below the detection limit of 4 ppm (Appendix B).

Comparison of normative and modal quartz-feldspar data (Fig. 16a, b) reveals a shift in the normative composition towards orthoclase. Probably this is because in the norm calculation all of the potassium is arbitrarily put into orthoclase whereas potassium occurs in other minerals in the actual rock. This shift would be especially prominent in rocks such as diorites with abundant K-bearing mafic minerals (e.g. biotite).

The dioritic rocks are characterized by low differentiation indices and the presence of normative diopside (Fig. 29) which is typical of mafic calc-alkalic granitoid rocks (e.g. Cawthorne et al., 1976). The range in compositions of the dioritic samples is evident on

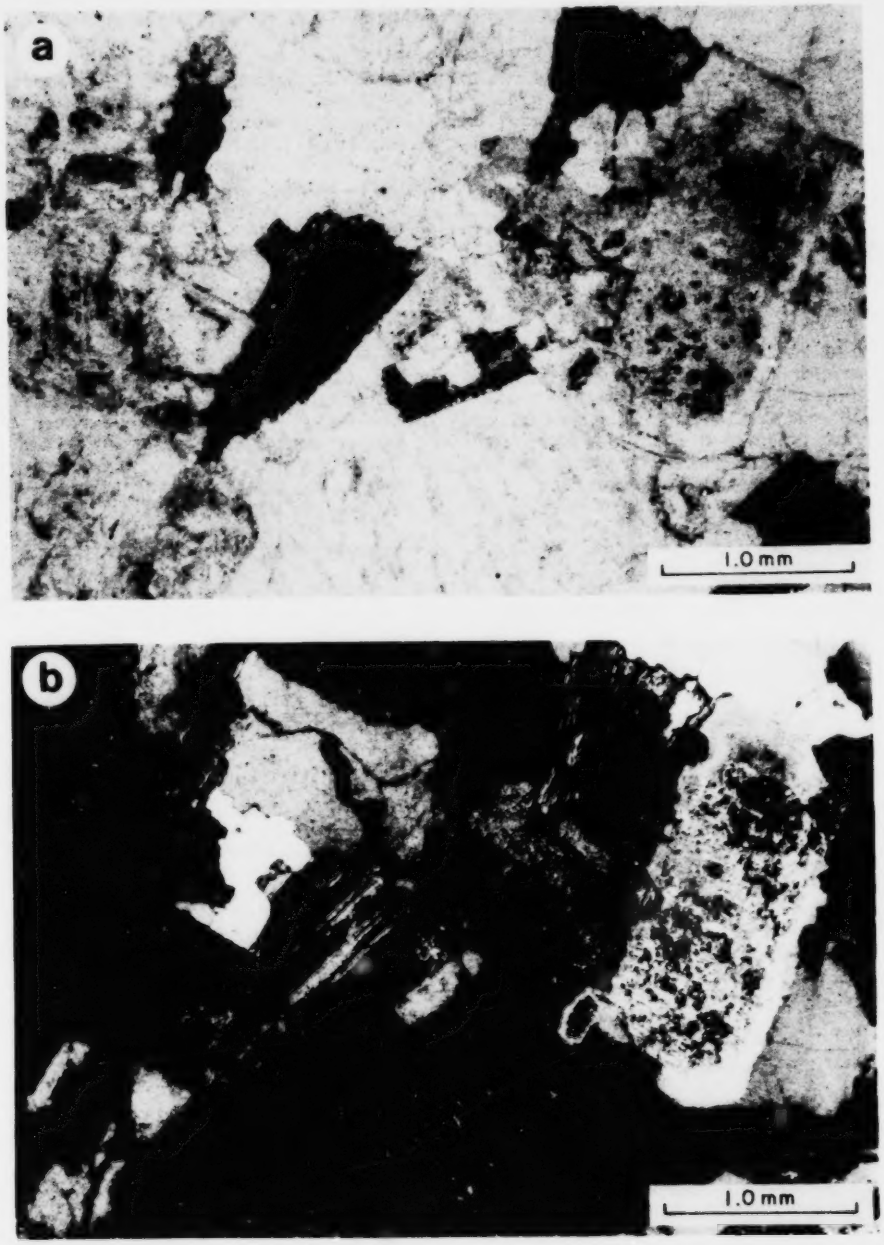

Figure 20. Biotite granodiorite of the Boisdale Hills Pluton, containing microcline, plagioclase, quartz and partially chloritized biotite. Sample 1356, (a) plane polarized light, (b) cross polarized light.

Figure 29, and also on the AFM diagram (Fig. 30). This variation may in part be due to alteration, but the main source is probably magmatic variability. The dioritic unit is not a single rock type, but both petrographically and chemically is composed of a variety of subphases of uncertain relationship.

Hornblende Granodiorite

Only two samples from the hornblende granodiorite were selected for analyses, because of limited sampling and the highly sheared and altered character of most outcrops. Both samples are relatively high in SiO_2, reflected in the high modal quartz content in spite of a fairly high mafic mineral content (average 15 per cent) and abundance of amphibole. Other major element contents are consistent with the SiO_2 content and show no anomalous features (Fig. 24). The hornblende granodiorite appears to be more evolved than the biotite hornblende granodiorite (Fig. 30), but tends to contain less excess Al_2O_3 (Fig. 29), probably reflected in its higher amphibole content (Cawthorne et al., 1976). Otherwise, the relatively minor content of biotite does not appear to have a chemical explanation, and must somehow be related to crystallization conditions.

Trace element abundances are generally similar to average values for other Cape Breton granitoid rocks of similar SiO_2 content, although one of the samples is somewhat high in U and Pb (Figs. 25, 27 and 28). In most respects these rocks are chemically similar to the biotite hornblende granodiorite described next.

Biotite Hornblende Granodiorite

The 13 analyzed samples from the biotite hornblende granodiorite range from about 59 to 70 per cent SiO_2, but most samples cluster around the mean of about 65 per cent, slightly lower than the hornblende granodiorite described above. Major element ranges are generally similar to those in other Cape Breton granitoid rocks of similar SiO_2 content except for being somewhat high in Al_2O_3 and low in Na_2O and K_2O (Fig. 24). This is reflected in the presence of considerable normative corundum (average 1.5 per cent) (Fig. 29).

Trace element values are somewhat scattered. Levels of Sr are similar to those in other Cape Breton granodiorites, but Rb and Ba are somewhat low and Ba has an especially wide range (Fig. 25). However, the samples show a normal trend on the Ba-Rb-Sr ternary diagram (Fig. 26).

The metals Cu, Mo, Pb and Zn also show some spread (Fig. 27). Average Mo and Zn values are similar to average levels in other Cape Breton granitoid rocks of comparable SiO_2 content, but both Pb and Cu are generally lower than average, although two samples from widely separate areas, 1543 and 1212, are higher than average in both elements. F and U values are also similar to the average, whereas Sn values are generally lower (Fig. 28).

Biotite Granodiorite

As noted in the petrographic description previously, the biotite granodiorite has a distinctive overall appearance, but varies considerably in composition. Only 5 samples were analyzed and they range from granodiorite to granite in composition, with 65 to 71 per cent SiO_2 (Figs. 16b and 24). The two more mafic samples (1085 and 1296) are virtually identical to the biotite hornblende granodiorite in major and trace element chemistry (Figs. 24, 25, 27 and 28) and do in fact contain minor hornblende. Thus the relationship between these two units may be gradational. Two of the three more silicic samples still plot in the granodiorite field in both modal and normative mineralogy (Fig. 16), largely as a result of low K_2O (Fig. 24). Otherwise, the major and trace element compositions are similar to average values in other Cape Breton granitoid rocks of comparable SiO_2 content, except for low Rb (consistent with low K_2O), Pb, Cu (in two samples only), U and Sn (Figs. 24, 25, 27 and 28).

Syenogranite

The syenogranite is a very silicic rock, ranging from about 74 to 78 per cent SiO_2. It is correspondingly very low in TiO_2, $Fe_2O_3^T$, MnO, MgO, CaO and P_2O_5, relatively low in Al_2O_3, and high in Na_2O and K_2O (Fig. 24). Values of Ba, Rb and Sr are fairly typical for such felsic rocks (Figs. 25 and 26) although Ba and Rb are slightly low in most samples. The metals Cu, Mo and Zn are very low, as is normal, but Pb values are even lower than average. This feature seems typical of the Boisdale rocks in general, but is especially pronounced in these highly felsic rocks. U values are normal but Sn values in two samples are anomalously high (Fig. 29). F is relatively low.

The highly evolved chemistry is apparent both on the AFM diagram, where the samples cluster near the alkalies corner (Fig. 30), and from the very high differentiation indices of 92 to 95 (Fig. 29). However, the samples tend to contain less normative corundum than the granodioritic rocks (Fig. 29), a trend not generally consistent with calc-alkalic suites (Cawthorne et al., 1976).

Microgranite

The three analyzed samples from the microgranite have a narrow range of SiO_2 contents (67 to 69 per cent), overlapping with both the biotite hornblende granodiorite and the biotite granodiorite. Other major elements are also generally similar to those in the granodiorites and other Cape Breton rocks of comparable SiO_2 contents, but with lower MgO and CaO and much higher Na_2O (Fig. 24). This is reflected in the normative plot (Fig. 16b) on which the samples are closer to the plagioclase corner than most samples from the granodiorites as a result of the higher albite content.

Like the granodiorites, the microgranite is somewhat low in Rb (Fig. 25), but slightly higher Ba and lower Sr place the samples to the left of

Table 6. Typical mineral analyses from biotite granodiorite sample 1224, Boisdale Hills Pluton.

	Plagioclase			Biotite	
	Core	Rim	Small Grain	1	2
SiO_2	57.7	60.6	62.0	36.06	34.07
TiO_2	0.0	0.0	0.0	3.38	3.63
Al_2O_3	26.1	24.7	23.1	17.07	17.86
FeO	0.0	0.0	0.0	19.19	20.69
MnO	0.0	0.0	0.0	0.61	0.93
MgO	0.0	0.0	0.0	10.40	11.81
CaO	7.8	6.2	4.7	0.00	0.24
Na_2O	6.9	8.2	8.8	0.00	0.00
K_2O	0.1	0.1	0.5	9.72	6.35
Total	98.6	99.8	99.1	96.43	95.58
Cations	O=32	O=32	O=32	O=24	O=24
Si	10.4	10.8	11.1	5.45	5.16
Al^{iv}	0.0	0.0	0.0	2.55	2.84
Al^{vi}	5.6	5.2	4.9	0.49	0.35
Ti	0.0	0.0	0.0	0.38	0.41
Fe	0.0	0.0	0.0	2.42	2.62
Mn	0.0	0.0	0.0	0.08	0.12
Mg	0.0	0.0	0.0	2.34	2.67
Ca	1.5	1.2	0.9	0.00	0.04
Na	2.4	2.8	3.0	0.00	0.00
K	<0.1	<0.1	0.1	1.87	1.23
H	0.0	0.0	0.0	4.00	4.00
O	32.0	32.0	32.0	24.00	24.00
Or	0.1	0.1	2.6		0.51
Ab	61.5	70.4	75.1		
An	38.4	29.5	22.3		
Fe/Fe+Mg				0.52	0.51

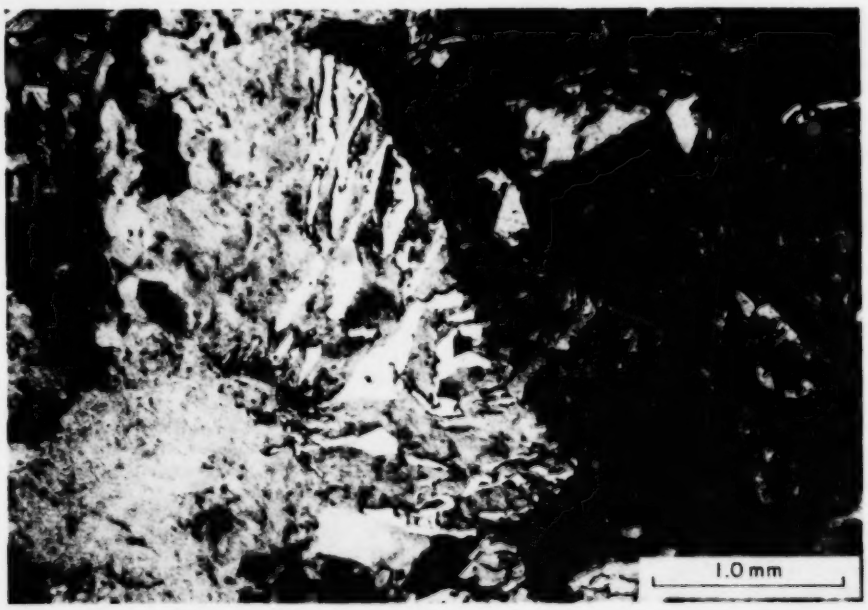

Figure 21. Granophyric intergrowths of quartz and alkali feldspar in syenogranite of the Boisdale Hills Pluton. Sample 1103, cross polarized light.

Table 7. Typical feldspar compositions in syenogranite and leucogranite, Boisdale Hills Pluton.

	SYENOGRANITE Sample 1053		LEUCOGRANITE Sample 1252	
	Plagioclase	K-feldspar	Plagioclase	K-feldspar
SiO_2	67.8	62.9	67.7	64.2
Al_2O_3	19.8	17.8	20.0	18.0
CaO	0.4	0.1	0.8	0.1
Na_2O	11.6	0.1	11.5	0.1
K_2O	0.1	16.4	0.1	16.5
Total	99.7	97.3	100.1	98.7
Cations	O=32	O=32	O=32	O=32
Si	11.9	12.0	11.9	12.0
Al	4.1	4.0	4.1	4.0
Ca	0.1	<0.1	0.1	<0.1
Na	3.9	<0.1	3.9	<0.1
K	<0.1	4.0	<0.1	4.0
Or	0.1	99.8	0.1	99.8
Ab	97.9	0.1	96.4	0.1
An	2.0	0.1	3.5	0.1

the granodiorites on the ternary Ba-Rb-Sr plot (Fig. 26). Cu, Mo, Pb and Zn values are similar to those in the granodiorites and other comparable Cape Breton rocks, with no anomalous samples (Fig. 27). U, Sn and F are similar to, or slightly higher than, average levels (Fig. 28).

The AFM diagram (Fig. 30) and the range of differentiation indices (Fig. 29) reveal more similarity to the biotite granodiorite than the biotite hornblende granodiorite. As mentioned previously, the microgranite is probably of hybrid origin and will be considered further in a later section.

Leucogranite

The analyzed leucogranite sample has SiO_2 content similar to the syenogranite, to which it is also similar in modal and normative compositions (Fig. 16). Major element (Fig. 24) and trace element (Figs. 25, 26, 27 and 28) abundances in the two units are also virtually identical, suggesting a close genetic relationship in spite of textural differences.

AGE RELATIONS

Relative ages of the various granitoid lithologies are somewhat uncertain because of the scarcity of exposed crosscutting relations. However, the dioritic rocks are clearly the oldest. They were intruded by the biotite hornblende granodiorite, which may have a gradational relationship with the biotite granodiorite. The latter unit is cut by a large dyke of syenogranite similar to the main syenogranite body which is therefore probably the youngest of these four major units. This intrusive sequence is consistent with chemical and petrographic trends, so that it is possible (although not necessarily correct) that these four units are comagmatic, i.e. evolved from a relatively mafic parent magma by differentiation processes. The leucogranite is so similar in chemical composition to the syenogranite that it seems likely that they crystallized from the same magma but under different physical conditions.

The two other units of the Boisdale Hills Pluton are more problematic in their relationships. The microgranite is located more or less between the syenogranite and leucogranite bodies (Fig. 2) and locally resembles the syenogranite in texture. It could have resulted from mixing of syenogranite magma with microdioritic rocks. In any case, it appears to have been late in the intrusive sequence.

The hornblende granodiorite southwest of Eskasoni could fit anywhere in the sequence or it could be unrelated to the other units because no crosscutting relations were observed. However, on the basis of petrological features, it is probably related to the dioritic rocks or the biotite hornblende granodiorite.

As previously discussed, field data provide only limited information concerning absolute ages of the granitoid rocks of the Boisdale Hills. The intrusions are certainly younger than the George River Group which they have intruded, but the age of the George River Group is itself not well defined. Most recent estimates suggest a late Hadrynian age, in part time-equivalent of the late Hadrynian Fourchu Group (Keppie, 1982b). Probably all of the intrusions are older than the Middle Cambrian Bourinot Group.

Radiometric age data generally support the late Hadrynian to early Cambrian age for the plutons inferred from the above reasoning. Samples from two separate localities in the syenogranite were analyzed by Cormier (1972); two

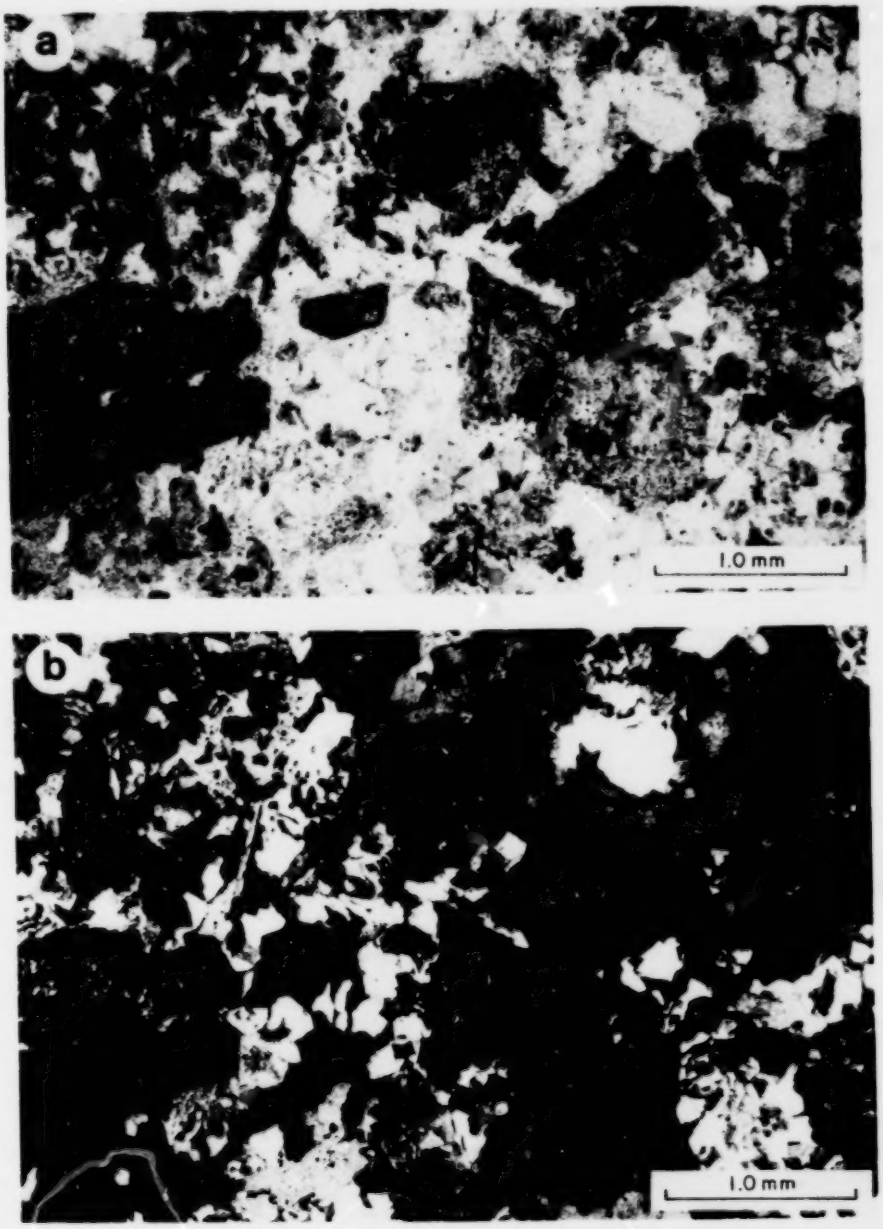

Figure 22. Microgranite of the Boisdale Hills Pluton showing altered plagioclase grains in a subgranophyric groundmass with minor chloritized biotite and amphibole. Sample 1449, (a) plane polarized light, (b) cross polarized light.

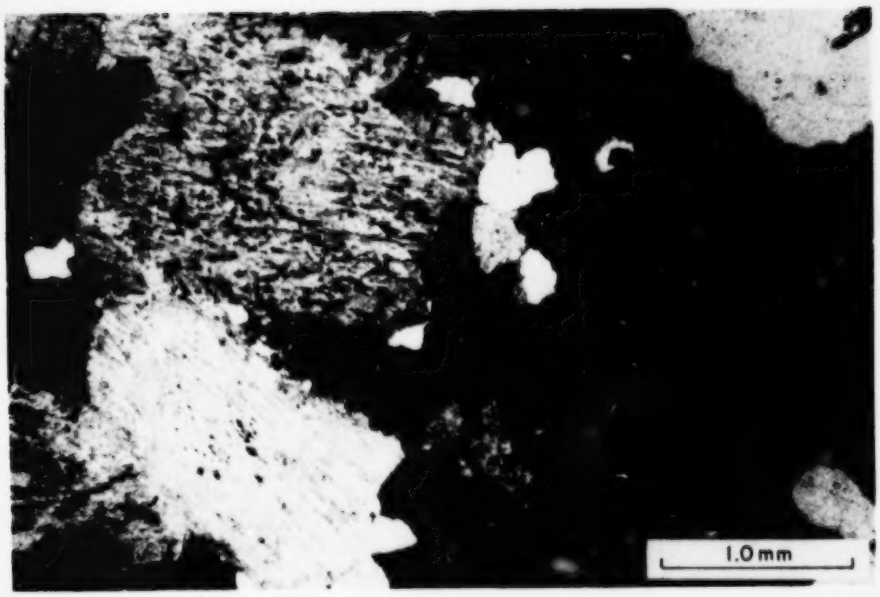

Figure 23. Leucogranite of the Boisdale Hills Pluton containing perthite, quartz (right, with undulatory extinction) and altered biotite (centre). Sample 1252, cross polarized light.

samples from the vicinity of locality 1103 at the northeastern end of the body gave a whole-rock Rb/Sr isochron age of 552 ± 70 Ma and a suite of seven samples from the quarry on the western side of the intrusion gave a similar age of 563 ± 31 Ma, both ages as recalculated by Keppie and Smith (1978) using current decay constants. Because of the large error ranges, these ages overlap with a K/Ar biotite age of 502 ± 20 Ma, probably from the biotite granodiorite in the vicinity of sample 1224 just south of MacAulays Lakes (Fig. 2) reported by Wanless et al. (1968). They also overlap with the age of 508 ± 70 Ma obtained from a combined biotite and whole-rock isochron for samples probably from biotite hornblende granodiorite north of sample locality 1199 near MacAulays Lakes (Fig. 2). These ages are obviously of little use in interpreting the relative ages of the various lithologies, but are consistent with the interpretation that all of the granitoid rocks are of late Hadrynian-early Cambrian age and hence part of one igneous episode.

SPRUCE BROOK PLUTON

FIELD OBSERVATIONS

The Spruce Brook Pluton is a small but heterogeneous intrusion of largely dioritic to tonalitic composition with lesser amounts of granite. Mapping proved difficult because of petrologic variations, intense shearing and poor exposure. Representative outcrops occur in Spruce Brook and on the logging road on the southwestern part of the Pluton (Fig. 2).

The Spruce Brook Pluton is separated from the Boisdale Hills Pluton by metasedimentary rocks of the George River Group and Devonian sedimentary rocks of the McAdam Lake Formation (Fig. 2). To the southwest and east the Pluton is bounded by metavolcanic rocks (herein assigned to the Fourchu Group) and Cambro-Ordovician sedimentary units (Hutchinson, 1952; Weeks, 1954). A small body of sheared granodioritic rocks on the southern margin of the metavolcanic unit is probably part of the Pluton.

Contact relations between the granitoid rocks and these various country rock units are not well understood. The relationship with the metavolcanic rocks is considered to be intrusive on the basis of what appear to be sheared granitoid bodies of uncertain form at several places within the metavolcanic section. The eastern contact of the Pluton with the Cambro-Ordovician sedimentary rocks is even more problematic. Helmstaedt and Tella (1972, 1973) and Hutchinson (1952) mentioned local hornfelsing of Cambrian strata in Spruce Brook. However, this was not confirmed during the current study, although quartz veining is present. The lack of evidence for contact metamorphism, the presence of extreme cataclasis in the granitoid rocks and field relations where granitoid rocks appear to sit above overturned sedimentary strata dipping under the granitoid rocks all suggest that the granitoid rocks may at least locally be thrust over the sedimentary rocks.

PETROGRAPHY

Petrographic characterization of the Spruce Brook Pluton is difficult because of its varied composition and lack of detailed sampling. The four samples selected for chemical analyses

Table 8. Means and standard deviations of analyses from the Boisdale Hills Pluton.

	Diorite n=10	Hornblende Granodiorite n=2	Biotite Hbld Granodiorite n=13	Biotite Granodiorite n=5	Syenogranite n=5	Microgranite n=3	Leucogranite (#1252) n=1
SiO_2	51.6 ± 4.6	66.4 ± 0.1	64.8 ± 2.3	68.7 ± 3.2	76.5 ± 1.5	68.1 ± 0.8	75.1
TiO_2	1.54 ± 0.87	0.39 ± 0.0	0.49 ± 0.13	0.33 ± 0.14	0.16 ± 0.05	0.61 ± 0.15	0.15
Al_2O_3	17.4 ± 1.9	15.3 ± 0.3	16.5 ± 0.8	15.6 ± 1.0	13.1 ± 0.65	15.4 ± 0.1	13.6
Fe_2O	10.6 ± 2.7	4.4 ± 0.02	5.2 ± 0.9	6.3 ± 2.2	1.1 ± 0.2	6.7 ± 2.6	1.21
MnO	0.18 ± 0.05	0.10 ± 0.00	0.10 ± 0.03	0.08 ± 0.02	0.04 ± 0.01	0.08 ± 0.02	0.03
MgO	4.8 ± 1.1	1.9 ± 0.3	2.4 ± 0.5	1.4 ± 0.9	0.21 ± 0.05	1.0 ± 0.4	0.10
CaO	7.5 ± 1.7	3.4 ± 0.1	4.3 ± 1.2	3.1 ± 1.0	0.59 ± 0.21	2.2 ± 0.6	0.43
Na_2O	3.6 ± 1.2	3.3 ± 0.0	3.3 ± 0.2	3.6 ± 0.1	4.2 ± 0.3	5.3 ± 0.7	4.4
K_2O	1.3 ± 0.9	3.3 ± 1.1	1.9 ± 0.6	2.0 ± 1.0	3.9 ± 0.5	2.5 ± 0.7	4.2
P_2O_5	0.23 ± 0.20	0.09 ± 0.00	0.11 ± 0.04	0.10 ± 0.02	0.03 ± 0.01	0.15 ± 0.05	0.03
Ba	282 ± 123	380 ± 50	325 ± 87	437 ± 174	415 ± 51	345 ± 54	390
Cu	23 ± 18	4 ± 4	15 ± 13	5 ± 8	2 ± 1	7 ± 3	3
F	400 ± 240	325 ± 49	370 ± 100	270 ± 30	180 ± 40	440 ± 70	200
Mo	1.6 ± 0.6	2.0 ± 0.5	2.0 ± 0.5	2.0 ± 0.4	1.8 ± 0.5	1.8 ± 0.3	2.0
Pb	4.7 ± 3.4	16 ± 11	9 ± 7	6 ± 7	4 ± 3	7 ± 1	6.0
Rb	67 ± 56	84 ± 16	70 ± 19	65 ± 18	133 ± 31	92 ± 15	150
Sn	2.6 ± 1.9	1.5 ± 0.1	2.6 ± 2.7	1.1 ± 0.3	4.5 ± 1.7	3.5 ± 0.9	5.0
Sr	300 ± 76	230 ± 21	249 ± 39	237 ± 29	71 ± 26	142 ± 13	46
U	0.9 ± 0.9	2.6 ± 1.8	1.8 ± 0.6	1.7 ± 0.5	3.5 ± 0.6	2.7 ± 0.6	2.7
W	<4	<4	<4	<4	<4	7 ± 5	<4
Zn	87 ± 26	88 ± 26	63 ± 18	46 ± 15	23 ± 5	58 ± 16	17

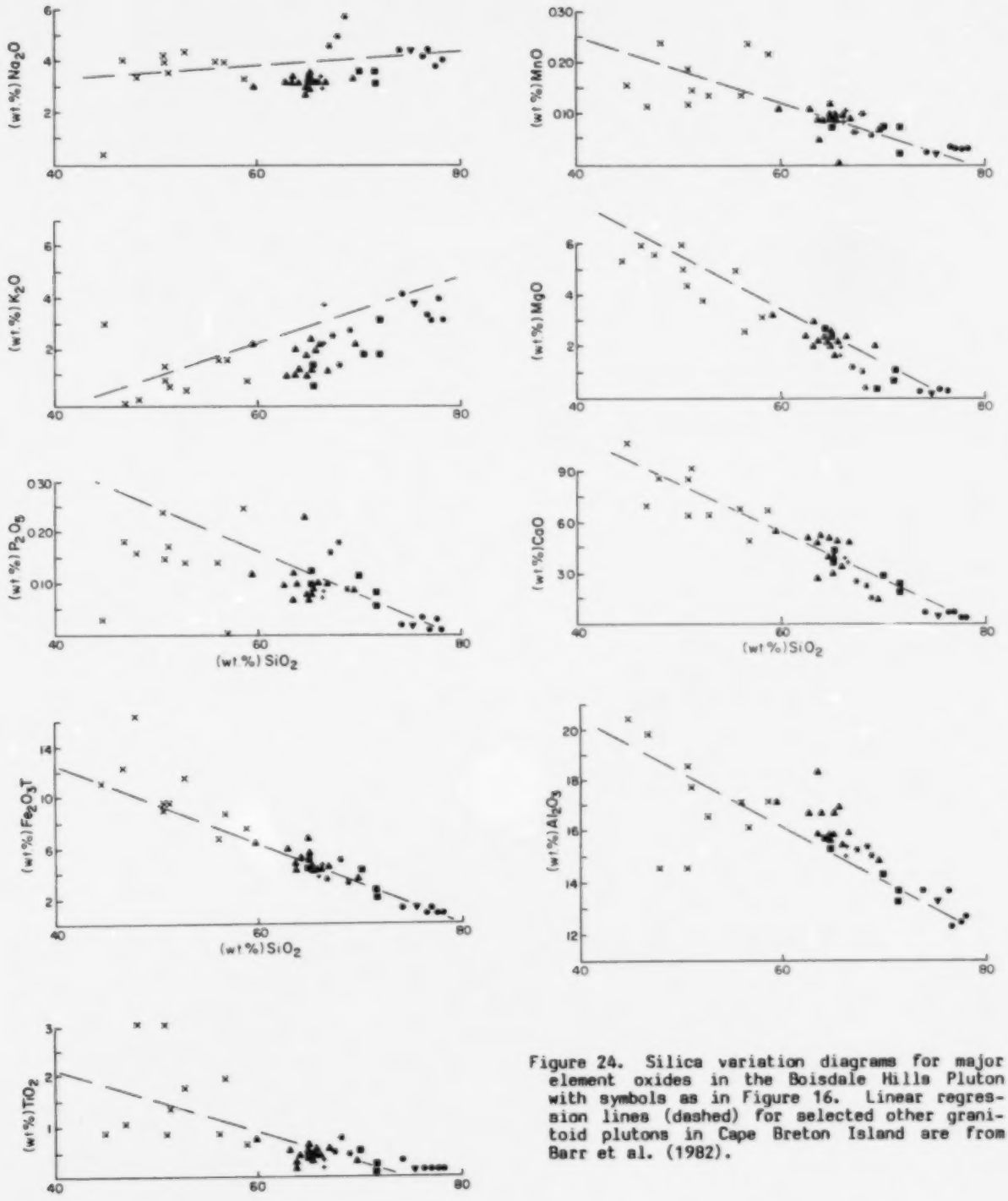

Figure 24. Silica variation diagrams for major element oxides in the Boisdale Hills Pluton with symbols as in Figure 16. Linear regression lines (dashed) for selected other granitoid plutons in Cape Breton Island are from Barr et al. (1982).

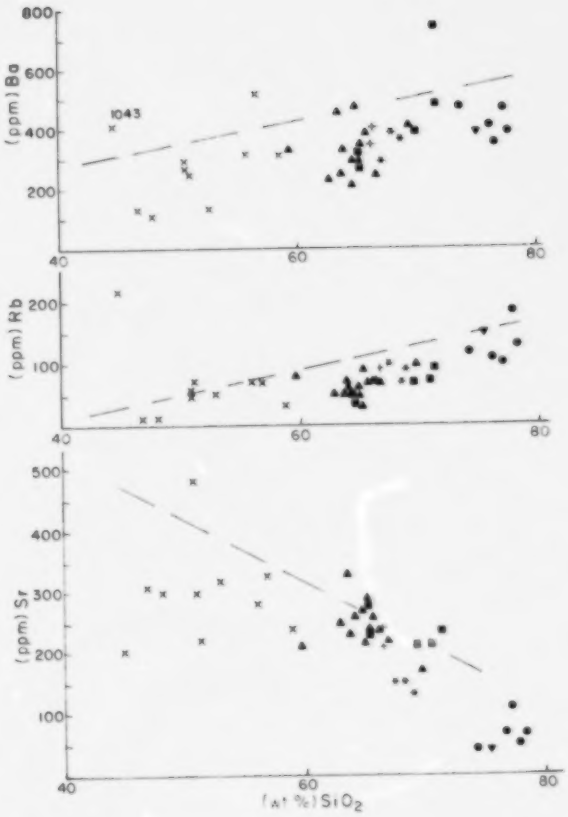

Figure 25. Silica variation diagrams for Ba, Rb and Sr in the Boisdale Hills Pluton with symbols and lines as in Figures 16 and 24.

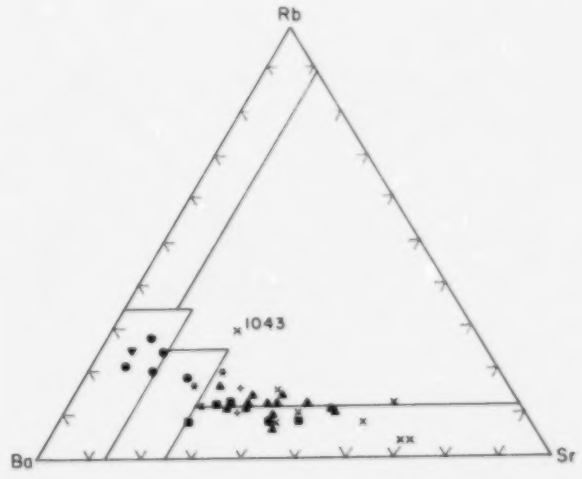

Figure 26. Ternary plot of Ba-Rb-Sr for the Boisdale Hills Pluton with symbols as in Figure 16 and fields as in Figure 12.

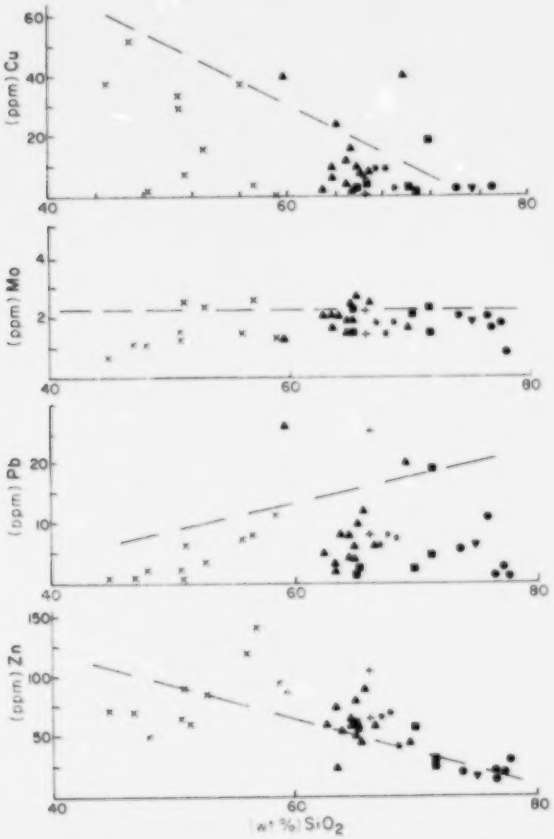

Figure 27. Silica variation diagrams for Cu, Mo, Pb and Zn in the Boisdale Hills Pluton with symbols and lines as in Figures 16 and 24.

appear to be typical and include leucotonalite, quartz diorite and granite (Fig. 31). Major minerals present are plagioclase, quartz, microcline (in three of the samples), amphibole and biotite. Accessory minerals other than opaques are not obvious.

The most characteristic feature of the samples is the evidence of brittle deformation. Quartz is either extensively granulated or exhibits strong undulatory extinction and subgrain boundary development (Fig. 32). Twinning in plagioclase is commonly bent or broken. Primary mafic minerals are also broken up and completely replaced by chlorite and epidote. Plagioclase is highly saussuritized and carbonate is very abundant.

CHEMISTRY

Although the leucotonalite and quartz diorite samples contain minor or no modal K-feldspar, they contain 8 to 13 per cent normative K-feldspar and hence plot in the granodiorite and monzodiorite fields in terms of normative mineralogy (Fig. 31). The quartz diorite contains only 49.8 per cent SiO_2, and differs from the average Cape Breton dioritic rock of

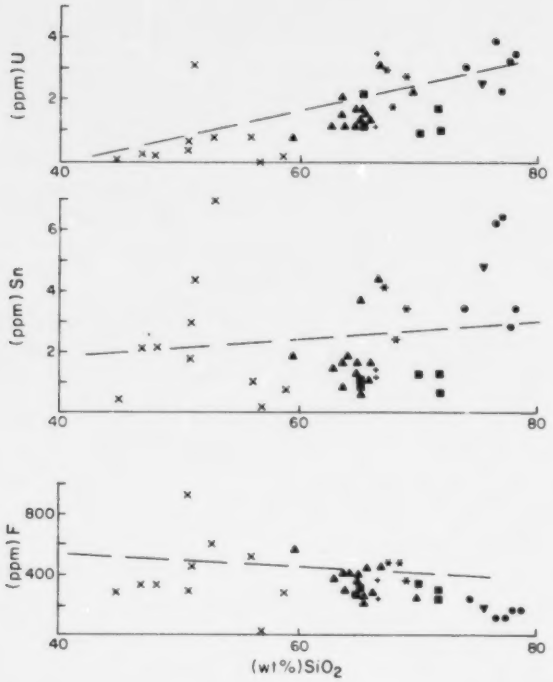

Figure 28. Silica variation diagrams for U, Sn and F in the Boisdale Hills Pluton with symbols and lines as in Figures 16 and 24.

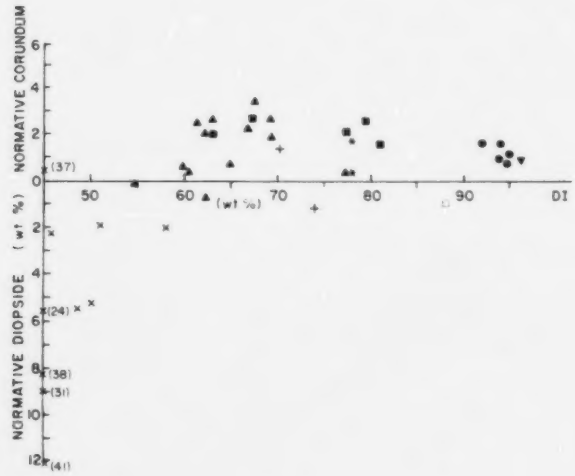

Figure 29. Plot of normative corundum or diopside against differentiation index (Thornton and Tuttle, 1960) for the Boisdale Hills Pluton with symbols as in Figure 16.

similar SiO_2 content in having much lower TiO_2 and P_2O_5 and higher MgO, Ba and Zn (Figs. 33, 34, 36 and 37).

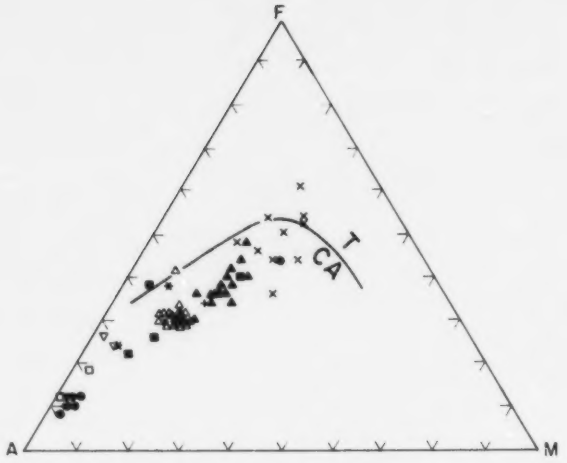

Figure 30. Ternary plot of $Na_2O + K_2O - FeO^T - MgO$ (AFM) for the Shunacadie and Boisdale Hills Plutons with symbols as in Figures 5 and 16. Tholeiitic/calc-alkalic dividing line is from Irvine and Baragar (1971).

The leucotonalite samples have SiO_2 levels (71.3 per cent and 68.0 per cent) similar to the granite sample (70.4 per cent), and corresponding levels of most other oxides and elements, except notably lower K_2O, Rb and U (Figs. 33, 34, 36 and 37). Three samples provide insufficient data to establish firm patterns, but compositions in general are consistent with those of rocks of similar SiO_2 content elsewhere in Cape Breton Island, except CaO may be lower. Leucotonalite sample 1603 contains especially abundant secondary calcite, but this is not reflected in the CaO analysis. Hence the calcite may contain redistributed, but not added, calcium. Low Pb is also a feature of these samples, like those of the Boisdale Hills Pluton described earlier.

AGE RELATIONS

The Spruce Brook Pluton has no contacts with other granitoid units and has not been dated by radiometric methods. Its overall dioritic composition suggests that it may be similar in age to the dioritic rocks of the Boisdale Hills Pluton.

It could also, or alternatively, be affiliated with the Coxheath Pluton to the east. The petrology of the Coxheath Pluton has not been systematically documented, but dioritic, granodioritic and granitic rocks are present (Pollock and Riddell, 1979; Chatterjee et al., 1980; Stevens et al., 1982; and personal observations). A range of samples collected in a reconnaissance survey of the Coxheath Pluton, as part of this study, show some petrological and chemical features similar to those of the Spruce Brook Pluton (Figs. 31 and 33-37). Exceptions include generally higher and more variable Ba, Sr, U, Cu and Mo in the Coxheath Pluton, features not surprising in a mineralized pluton. Various radiometric ages have been reported for the Coxheath Pluton, including 593 ± 28 Ma (K/Ar on hornblende from "syenodiorite"; Wanless et al.,

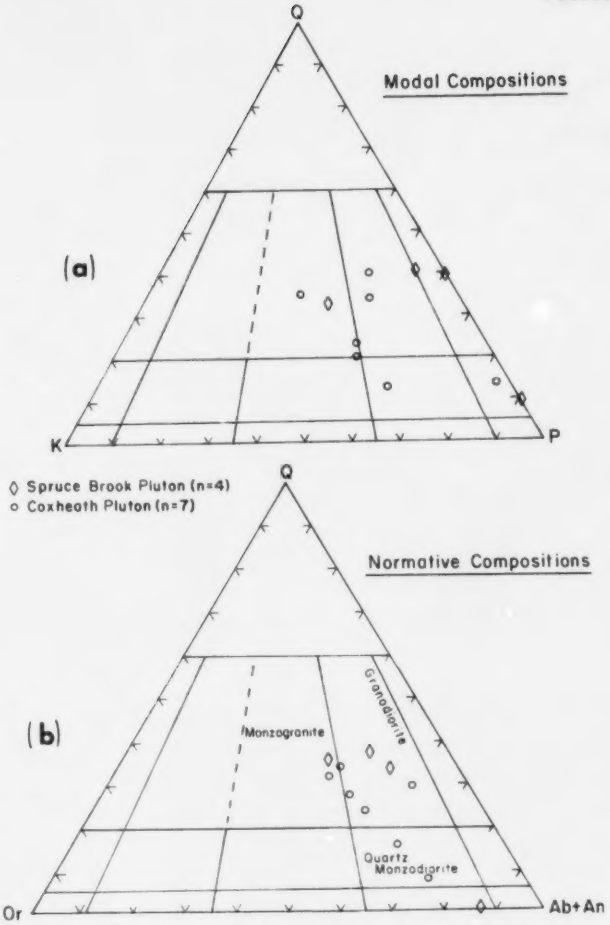

Figure 31. (a) Modal quartz-potassium feldspar-plagioclase ternary diagram for Spruce Brook and Coxheath Plutons. Fields are from Streckeisen (1976). (b) Normative quartz-orthoclase-albite+anorthite ternary diagram for Spruce Brook and Coxheath Plutons. Fields are from Streckeisen (1976).

1968), 569 ± 70 Ma (Rb/Sr, whole-rock and feldspar from granite; Cormier, 1972), and 700 ± 50 Ma (average K/Ar on hornblende from granodiorite; Stevens et al., 1982). These ages tend to be older than those from the dated units in the Boisdale Hills Pluton previously discussed although the data are not definitive because of large error limits on many of the numbers. However, they indicate that the Coxheath Pluton, the Spruce Brook Pluton, and hence possibly the dioritic units in the Boisdale Hills and Shunacadie Plutons, may be somewhat older than the other granitoid phases.

PETROGENETIC IMPLICATIONS

CORRELATION OF GRANITOID UNITS

Relationships among the three granitoid belts in the Boisdale Penninsula are quite speculative because no crosscutting relations were observed between the various units of the Shunacadie Pluton, the Boisdale Hills Pluton and the Spruce Brook Pluton. On the basis of the radiometric age data and field relations with the country rocks, it seems most likely that all of these granitoid rocks are late Hadrynian to early Cambrian.

The small dioritic body in the Shunacadie Pluton may be correlative with the dioritic unit of the Boisdale Hills Pluton, although amphibole compositions in the rocks appear to be rather different in TiO_2 and Na_2O (Tables 2 and 4) so this may not be the case. Similarly, the dioritic rocks of the Spruce Brook Pluton (and the Coxheath Pluton) may be correlated with these dioritic rocks. These units all display considerable petrographic and chemical variability (e.g. Figs. 38-42), a feature which has been observed in other Cape Breton dioritic units and attributed in a general way to crystal fractionation and multiple intrusion (Barr et al., 1982). Alteration may also be a significant factor, especially because these rocks are the oldest intrusive phases in an area of repeated igneous activity, undoubtedly accompanied by hydrothermal activity. A more detailed study is required to interpret their petrology. The relationship of these various dioritic units to the other, more felsic, granitoid units is unclear. Chemically, there is a considerable gap in SiO_2 content between the dioritic rocks and the biotite hornblende granodiorite of the Boisdale Hills Pluton (except for one sample) (Figs. 38 and 39). However, perhaps more sampling of the diorites would make the trends more compatible with a differentiation model.

The biotite granodiorite of the Shunacadie Pluton essentially lacks hornblende and is a somewhat more felsic unit than the biotite hornblende granodiorite of the Boisdale Hills Pluton. This is clear from the AFM diagram (Fig. 40), the differentiation indices (Fig. 41) and major and trace element variation diagrams (Figs. 38 and 39). Although the trends displayed on these diagrams do not prove that these two major rock types of the Boisdale Peninsula are cogenetic, it seems very likely, with the biotite granodiorite being the result of fractionation of amphibole and plagioclase. Some chemical features of the two units are very similar, such as low K_2O, Rb and Pb and high Al_2O_3 compared to other Cape Breton granodiorites.

The biotite granodiorite of the Boisdale Hills Pluton seems to have some features of both of the above units and in fact the five analyzed samples cover approximately the same range of SiO_2 contents as the two units combined (Fig. 38). Petrographic features also show similarities to both, with texture very like that in the biotite granodiorite yet locally containing minor amounts of hornblende. It may be that the area mapped as biotite granodiorite in the Boisdale Hills Pluton actually should be subdivided, consisting in part of biotite granodiorite and in part biotite hornblende granodiorite. However, this could not be done on the basis of available outcrop distribution. Alternatively, the unit may be transitional or gradational between the other two units. In any case a close genetic relationship is inferred for the three lithologies.

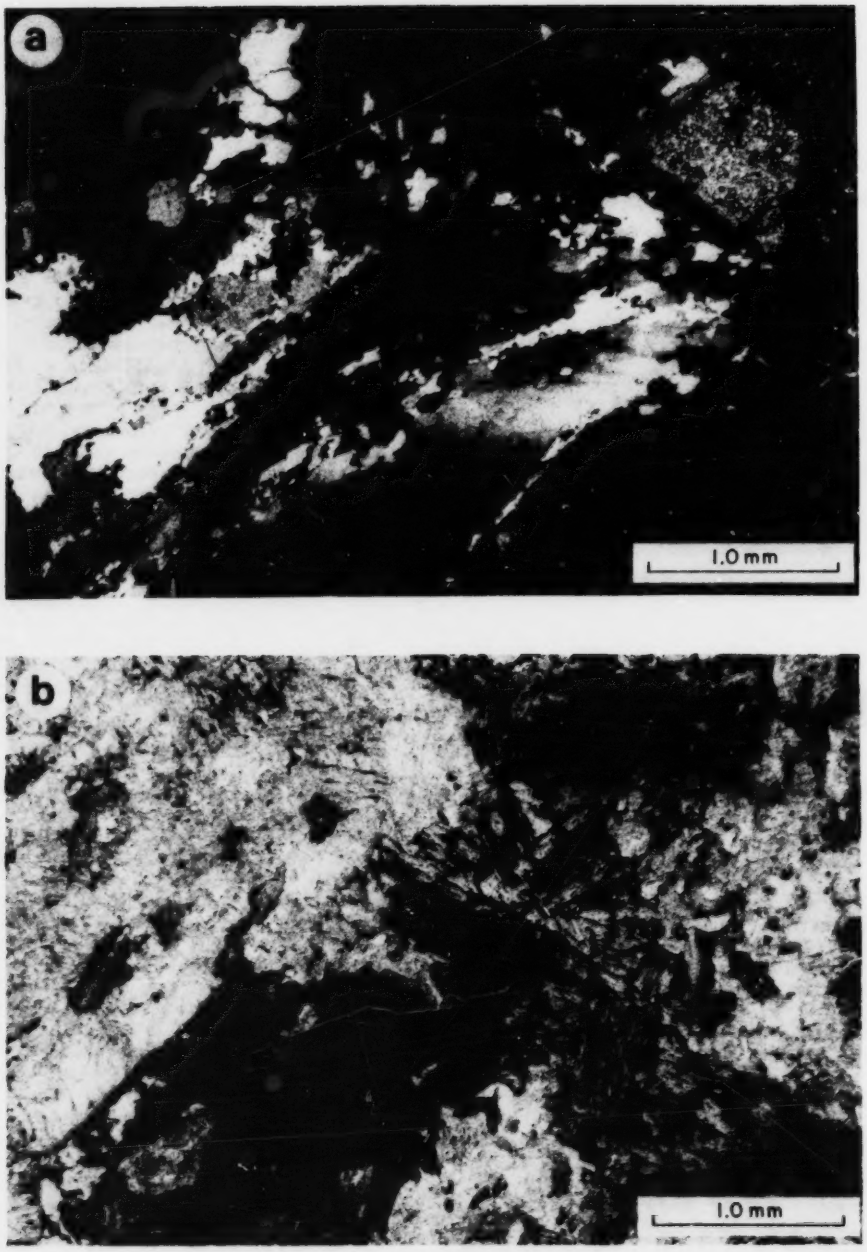

Figure 32. (a) Cataclased granite of the Spruce Brook Pluton. Sample 1577, cross polarized light. (b) Diorite of the Spruce Brook Pluton, consisting predominantly of altered plagioclase, amphibole (lower left) and chloritized biotite (centre). Sample 1594, plane polarized light.

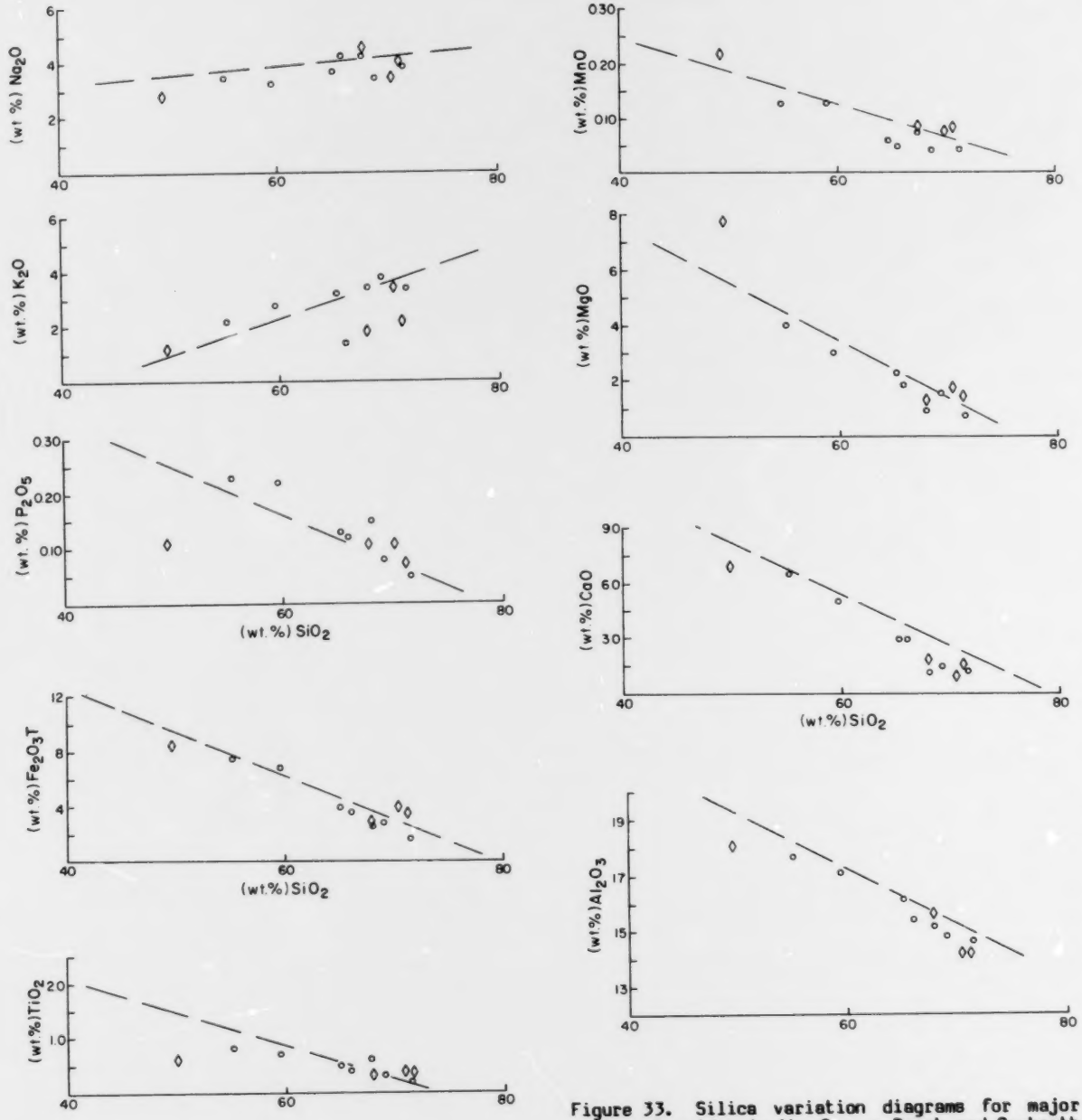

Figure 33. Silica variation diagrams for major element oxides in the Spruce Brook and Coxheath Plutons with symbols as in Figure 31. Linear regression lines (dashed) for selected other granitoid plutons in Cape Breton Island are from Barr et al. (1982).

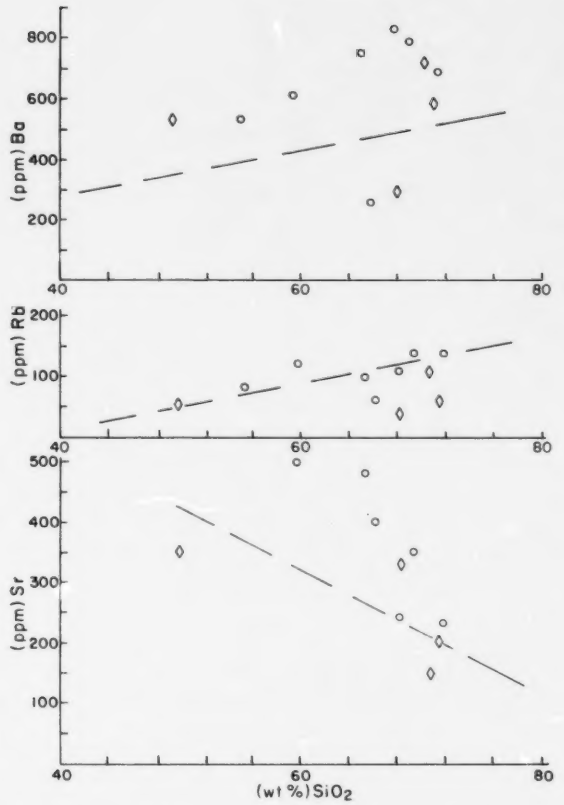

Figure 34. Silica variation diagrams for Ba, Rb and Sr in the Spruce Brook and Coxheath Plutons with symbols and lines as in Figures 31 and 33.

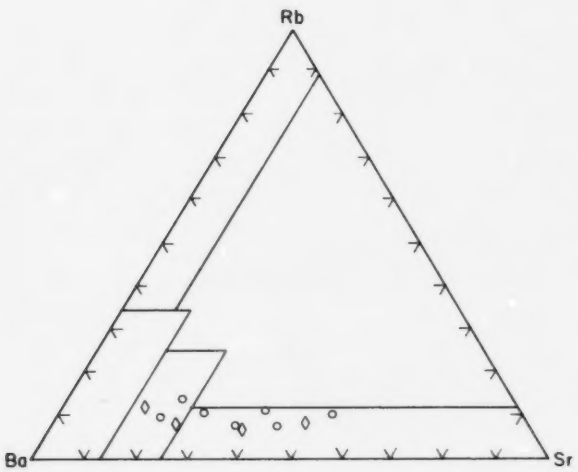

Figure 35. Ternary plot of Ba-Rb-Sr for Spruce Brook and Coxheath Plutons with symbols as in Figure 31 and fields as in Figure 12.

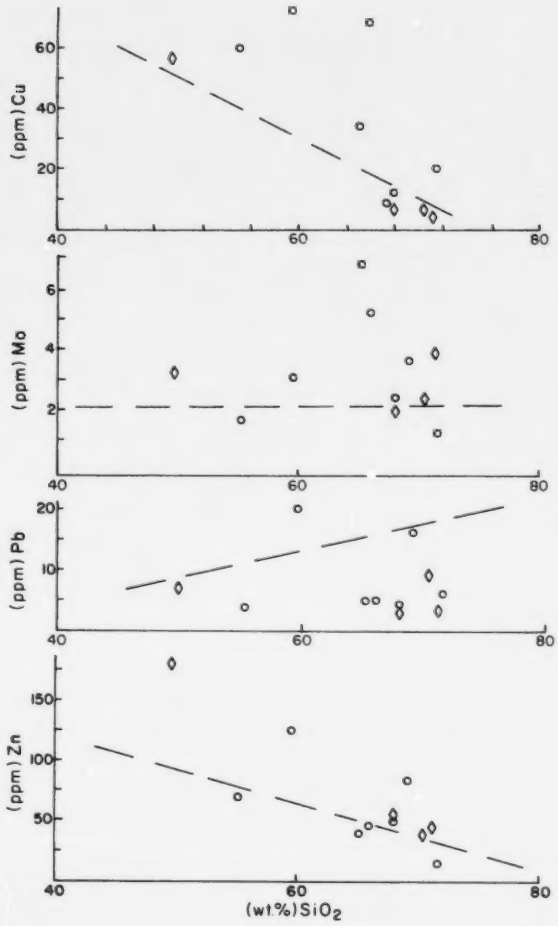

Figure 36. Silica variation diagrams for Cu, Mo, Pb and Zn in the Spruce Brook and Coxheath Plutons with symbols and lines as in Figures 31 and 33.

The hornblende granodiorite is difficult to relate to the other granodiorites because of its abundant amphibole combined with relatively high SiO_2, more or less intermediate between the hornblende biotite granodiorite and biotite granodiorite (Fig. 38). Chemical features are generally compatible with the other granodioritic units, and the reason for the increased abundance of amphibole is not apparent.

The more evolved rocks of the Boisdale Hills, including granite, syenogranite and the various leucogranite bodies are all interpreted to be late-stage intrusions. The striking chemical similarity of the leucogranites and the syenogranite suggests that they represent different levels or parts of the same magma body, the differences among them being primarily textural. Granophyric textures like those in the syenogranite are generally attributed to quenching under shallow epizonal conditions of a magma which retained water in solution (e.g. Hughes, 1982). Hence its presence indicates that the syenogranite crystallized at higher crustal

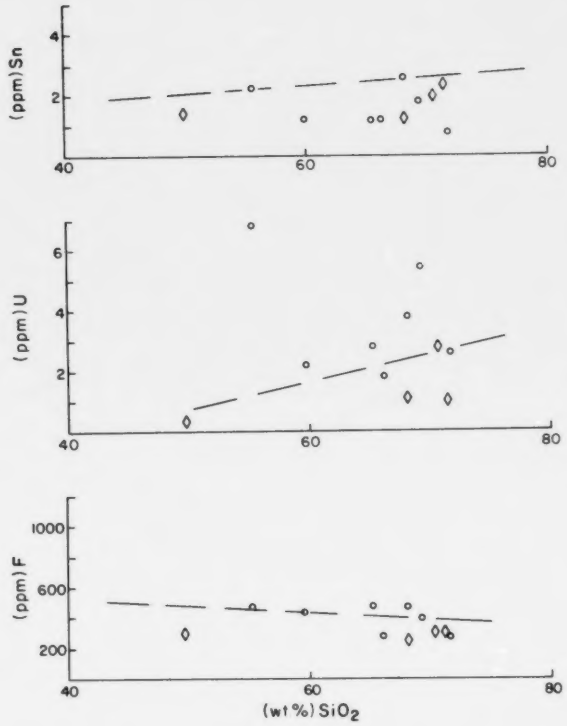

Figure 37. Silica variation diagrams for U, Sn and F in the Spruce Brook and Coxheath Plutons with symbols and lines as in Figures 31 and 33.

levels than the other leucogranitic rocks which lack granophyre.

The microgranite is interpreted to be a zone of hybridization between the syenogranite magma and possibly an older fine grained diorite. Although the physical conditions under which this might take place are obscure, the range in textures and mineralogy within this unit from veined microdiorite to syenogranite are in support of this origin.

The relationship of the varied rocks of the Spruce Brook Pluton to those discussed above is difficult to assess. Petrographic and chemical features are compatible with a close relationship, but this may only reflect similar source rock(s) and parallel evolution. It is interesting that the seven samples from the Coxheath Pluton cover nearly the same chemical range as the 65 samples from the Shunacadie and Boisdale Hills Plutons (Figs. 38-41). With more sampling, the Spruce Brook Pluton could probably yield a similar range. This suggests that these two small Plutons are correlative, and further that their histories may include the same range of events as the much larger Shunacadie and Boisdale Hills Plutons.

PETROGENESIS

As documented in earlier sections, the plutonic rock units of the Boisdale Peninsula are characterized by different primary (igneous) textural, mineralogical, and/or chemical features. These differences are not likely to have resulted from host-rock contamination, deuteric/hydrothermal alteration or other secondary processes, although these have certainly taken place to varying extents and may be largely responsible for internal variations within single lithologic units.

Explanations for the variety of rock types present as mappable units include:

1. Differentiation processes, whereby a series of increasingly more felsic magmas are derived from a mafic or intermediate parent magma.

2. Partial melting processes, in which case a series of magmas of varying compositions are produced, perhaps by varying degrees of partial melting or by melting of different parent materials, either all at approximately the same time or at different stages of a thermal event (or possibly more than one thermal event).

3. Mixing of magmas formed by the mechanisms above, or intrusion of older, probably partly crystalline, units by younger magmas generated by either of the above mechanisms.

4. Different conditions of magma crystallization (e.g. pressure, temperature, water content).

5. Combinations of the above.

The leucogranites and syenogranite as already mentioned are interpreted to be an example of explanation 4 above, being late-stage, highly evolved magmas crystallized at different depths with P_{H2O} probably an important variable. The microgranite may be an example of explanation 3 above, the result of some interaction between diorite and syenogranite/leucogranite magma.

However, the relative importance of the first two mechanisms, differentiation and anatexis, in the formation of complex intrusions such as those on the Boisdale Peninsula is difficult to assess. The samples as a whole display typical calc-alkalic differentiation trends for both major (e.g. Figs. 39 and 40) and trace elements (Figs. 39 and 42). This is consistent with a differentiation model, but does not prove it. Alternatively, varying amounts or physical conditions of partial melting can produce a range of melt compositions similar to that observed in the map area (e.g. Winkler, 1976).

The nature of the source rock(s) for the magma(s) is problematic. Little is known about the crust and mantle under southern Cape Breton

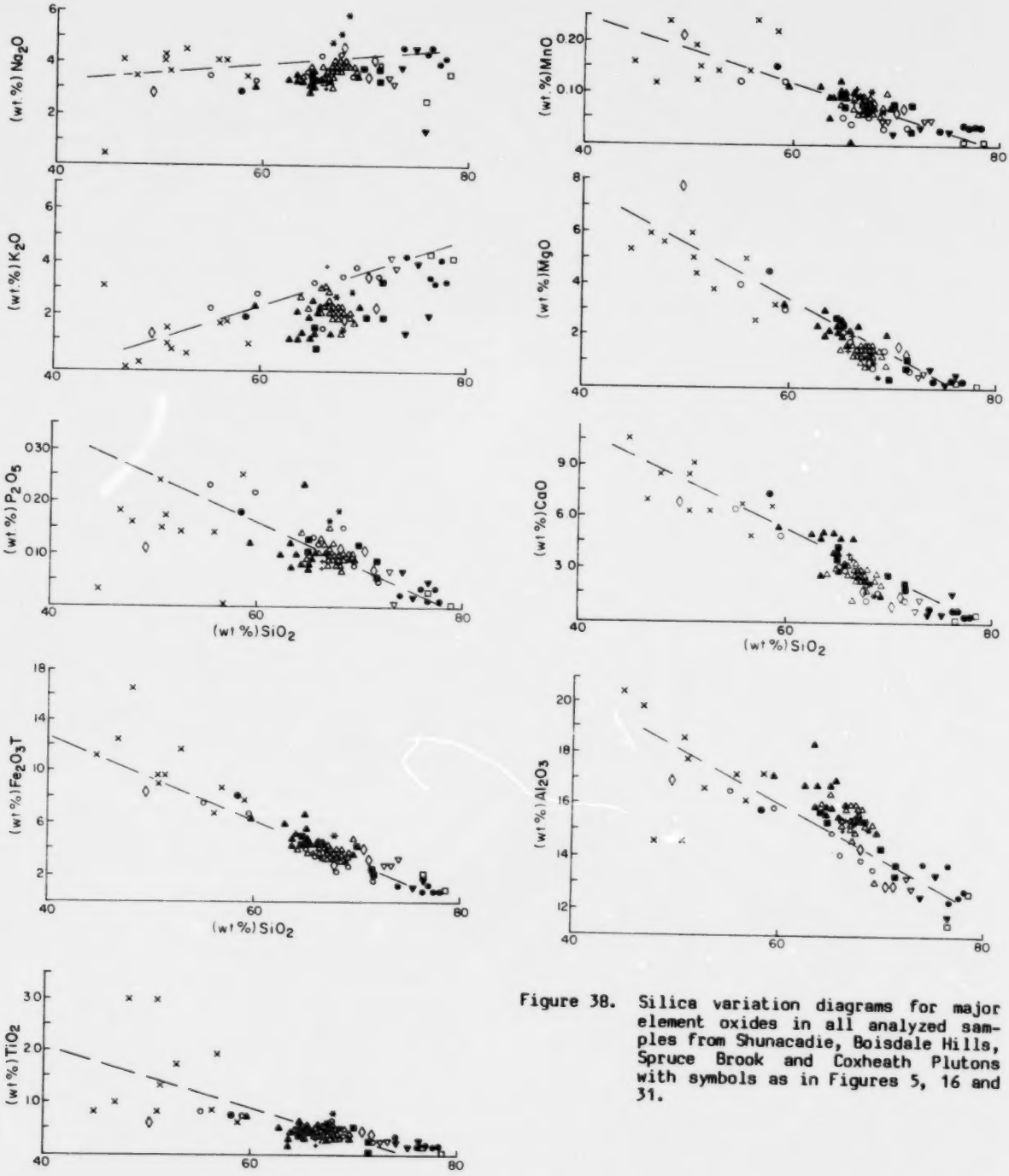

Figure 38. Silica variation diagrams for major element oxides in all analyzed samples from Shunacadie, Boisdale Hills, Spruce Brook and Coxheath Plutons with symbols as in Figures 5, 16 and 31.

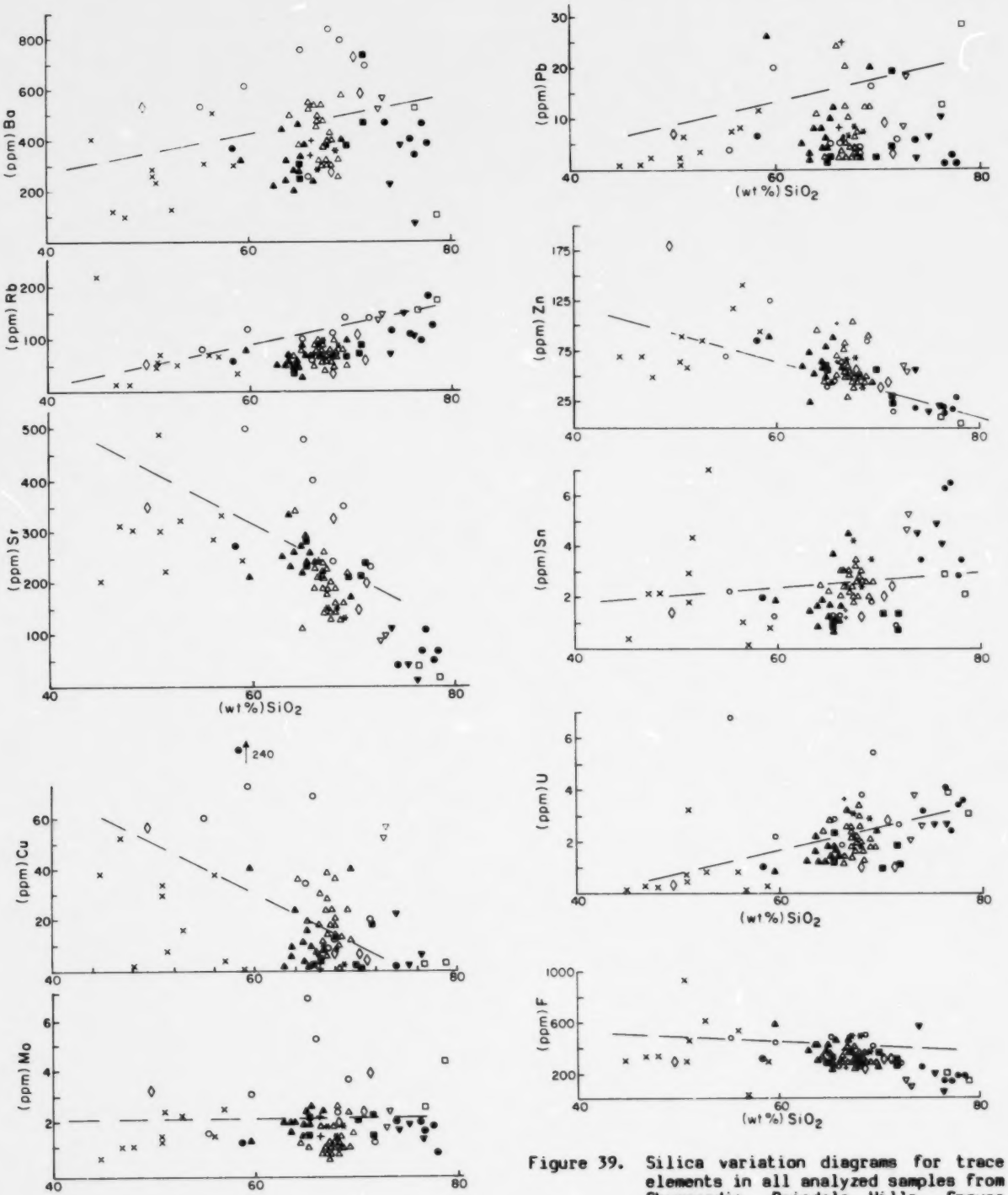

Figure 39. Silica variation diagrams for trace elements in all analyzed samples from Shunacadie, Boisdale Hills, Spruce Brook and Coxheath Plutons with symbols as in Figures 5, 16 and 31.

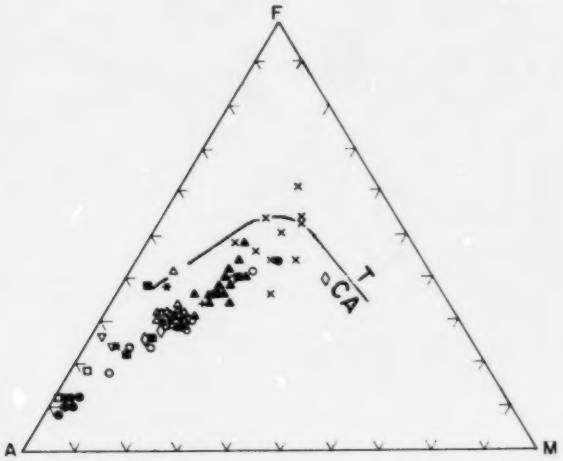

Figure 40. Ternary plot of $Na_2O + K_2O - FeO^T - MgO$ (AFM) for all analyzed samples from Shunacadie, Boisdale Hills, Spruce Brook and Coxheath Plutons, with symbols as in Figures 5, 16 and 31. Tholeiitic/calc-alkalic dividing line from Irvine and Baragar (1971).

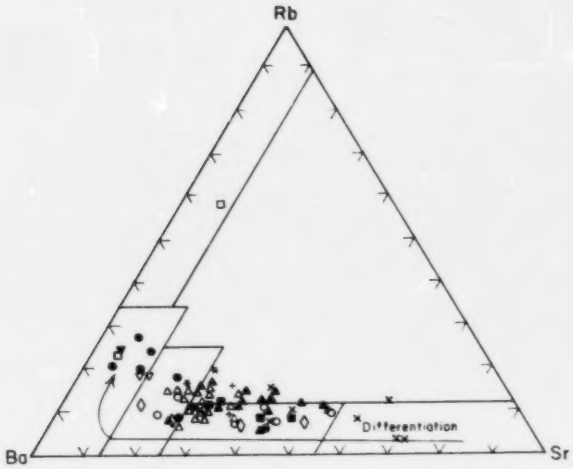

Figure 42. Ternary plot of Ba-Rb-Sr for all analyzed samples from Shunacadie, Boisdale Hills, Spruce Brook and Coxheath Plutons, with symbols as in Figures 5, 16 and 31.

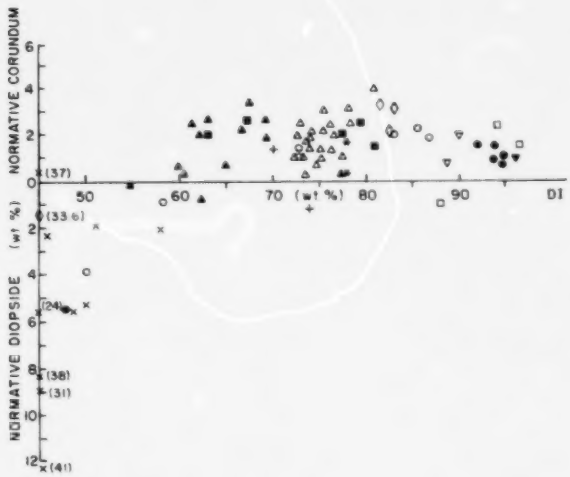

Figure 41. Plot of normative corundum or diopside against differentiation index (Thornton and Tuttle, 1960) for all analyzed samples from Shunacadie, Boisdale Hills, Spruce Brook and Coxheath Plutons with symbols as in Figures 5, 16 and 31.

Island beneath the George River Group. No direct evidence is provided by xenoliths in the granitoid rocks of the Boisdale Peninsula, as all appear to be from the George River or Fourchu Group host rocks. The plutonic rocks have many characteristics of I-type granitoids, considered to be derived from primitive mantle or deep-crustal igneous sources (Chappell and White, 1974). These characteristics include the abundance of hornblende and sphene and absence of muscovite, the broad spectrum of compositions from mafic to felsic, and near-linear variation diagrams. The initial ratios of $^{87}Sr/^{86}Sr$ also seem to be less than 0.706, a characteristic feature of I-type intrusions. Poole (1980) reported an initial ratio of 0.7055 ± 0.0004 for biotite granodiorite and granite from the Shunacadie Pluton and Cormier (1972) (recalculated by Keppie and Smith, 1978) found initial ratios of 0.701 ± 0.002 and 0.704 ± 0.002 for the syenogranite of the Boisdale Hills Pluton.

One feature which is not consistent with an I-type classification is the presence of more than one per cent normative corundum in many of the rocks other than the diorites. However, it has been shown that peraluminous compositions can originate in various ways (Cawthorne et al., 1976; Halliday et al., 1981), most of which are compatible with the origin postulated for I-type granitoid rocks. In this case, a probable explanation is fractionation of amphibole, an abundant mineral in the more mafic rock types. Analyses of these amphiboles showed that they contain appreciable Na and K (Tables 1, 2 and 4) and are diopside-normative. Hence their removal by fractionation processes could result in increasingly peraluminous compositions like the

trend in Figure 41. However, unlike some other calc-alkalic suites (e.g. Cawthorne et al., 1976) the amount of normative corundum does not continue to increase with differentiation index and SiO_2, but tends to decrease in the most felsic units. This may be related to fractional crystallization of biotite which inhibited further build-up of alumina in these magmas.

This explanation does not account for the absence of normative corundum in other plutons of similar age in southern Cape Breton Island (Barr et al., 1982). The main difference seems to be relatively high Al_2O_3 and low alkalies in granodioritic rocks of the Boisdale Hills. Together with other fairly consistent differences such as low Pb, this may reflect the composition of deep crustal or mantle rocks under the Boisdale Hills.

There is no evidence that assimilation or anatexis of pelitic metasedimentary rocks is the reason for the peraluminous compositions. No pelitic xenoliths were observed and no older pelitic units are known to be present in the region. Hence these rocks are not considered to be primary peraluminous melts in the sense of the S-type granitoids of Chappell and White (1974).

TECTONIC SETTING

Various workers have suggested that the late Hadrynian-early Cambrian granitoid plutons in southern Cape Breton Island were emplaced in conjunction with a late Hadrynian Avalonian (or Cadomian) Orogeny (e.g. Helmstaedt and Tella, 1973; Keppie, 1982a and b). Like other plutons of similar age in southern Cape Breton Island, the plutonic rocks of the Boisdale Peninsula are a "compositionally expanded series" of calc-alkaline rocks, characteristic of Andean-type and island-arc magmatism (Pitcher, 1979). The granitoid rocks in the Boisdale Peninsula are approximately the same age as, or somewhat younger than, the volcanic rocks of the Fourchu Group. These volcanic rocks have been interpreted to have calc-alkalic island-arc affinities (Keppie et al., 1979). The plutons are apparently older than and not genetically related to the volcanic rocks of the Bourinot Group which seem to have alkalic affinities (Keppie and Dostal, 1980). Although the nature of the late Hadrynian orogenic event is not really clear, Keppie (1982b) suggested that Cape Breton Island was part of an ensialic volcanic island arc with a northwesterly dipping subduction zone.

The plutons were emplaced to relatively shallow crustal levels, as suggested by the generally low grade of regional metamorphism in the country rocks and low pressure contact metamorphic assemblages (Milligan, 1970; Helmstaedt and Tella, 1973), the presence of approximately coeval volcanic rocks (Fourchu Group) and granophyric textures in the syeno-granite. Deeper levels of the intrusions may be exposed in the southwestern part of the Boisdale Peninsula, where country rock metamorphic grades appear to be higher.

ECONOMIC IMPLICATIONS

No significant economic mineralization in the granitoid rocks of the Boisdale Hills was recognized during this study. Disseminated pyrite is common in the dioritic rocks and pyrite with minor chalcopyrite and molybdenite were noted locally on fracture surfaces. Scheelite has apparently been found in the biotite granodiorite of the Boisdale Hills Pluton in drill core from near its northeastern end (S. Sears, personal communication, 1980), but was not confirmed during this study.

There is little evidence for unusual late-stage magmatic and/or hydrothermal activity, with a notable paucity of pegmatites, greisens or quartz veins. However, along the central eastern margin of the Boisdale Hills Pluton, the adjacent George River Group rocks contain several minor mineralized zones in marbles and skarns. These zones contain pyrite, chalcopyrite, pyrrhotite, sphalerite, galena, magnetite and, locally, scheelite (Chatterjee in Milligan 1970; Chatterjee, 1977; 1983). With the exception of the mineralization in Christmas Brook near Eskasoni, these zones are adjacent to the biotite granodiorite. However, it seems more likely that the presence of carbonate rocks rather than the composition of the adjacent granitoid was the essential factor, and that the main function of the intrusion was to provide heat.

The granitoid rocks are obviously not "specialized" in the sense of Tischendorf (1977) and Stemprok (1979). Indicator chemical features such as F, Sn, Rb/Sr, K/Na and K/Rb are all negative (Table 9). If economic mineralization does occur with these granitoid rocks, it is almost certain to be of the Cu-Mo association. However, there is also no evidence for the chemical features likely to be related to this type of mineralization, such as wide ranges and high variability in Cu, Pb, Zn and Mo values (e.g. Barr, 1982; Barr et al., 1982). Although the Boisdale Peninsula intrusions appear to be relatively high level (epizonal), especially the northern syenogranite, it is possible that the potentially economic mineralization, if present in the roof zone, has been removed by erosion. The deeper parts of relatively dry granitoid bodies, dominated by biotite granites, are in general barren (Strong, 1981).

In this context it is interesting to note that the Carboniferous sedimentary sequences nonconformably overlying the plutons on the east contain significant copper occurrences (Chatterjee, 1983). Barite occurs in shear zones near the same nonconformity on the northwestern side of the Shunacadie Pluton. Such areas may be the most promising sites for exploration in the area.

On the basis of well developed porphyritic textures and intense hydrothermal alteration, the Coxheath Pluton may be a higher level intrusion than those in the Boisdale Hills. Intense shearing makes it difficult to know whether or not the Spruce Brook Pluton had similar primary textures. The Spruce Brook-Coxheath belt could be part of the Boisdale Hills Pluton, offset to

Table 9. Selected geochemical features of granitic rocks in the Boisdale Hills compared to average and specialized granites*.

	F	Sn	Rb/Sr	K/Rb	K/Na
Shunacadie Pluton					
Biotite Granodiorite	320	2.7	0.4	274	0.8
Granite	450	5.1	1.6	234	1.4
Leucogranite	190	2.6	5.1	209	1.6
Boisdale Hills Pluton					
Hornblende Granodiorite	325	1.5	0.4	330	1.1
Biotite Hornblende Granodiorite	370	2.6	0.3	225	0.6
Biotite Granodiorite	270	1.1	0.3	255	0.6
Syenogranite	180	4.5	1.9	243	1.0
Microgranite	440	3.5	0.7	226	0.5
Leucogranite	200	5.0	3.3	232	1.1
Spruce Brook Pluton					
Granite	300	2.0	0.3	275	0.7
Coxheath Pluton					
Granite/Granodiorite	400	1.7	0.3	222	0.9
Average Granite	800	3.0	0.06-0.34	>100	≈1.2
Specialized Granite	3700 ±1500	40 ±20	4-16	<100	≈1.6

* Data from Vinogradov (1962), Plimer and Elliott (1979), Tischendorf (1977), and Smith and Turek (1976).

its present position on the fault systems defined by Giles (1982, 1983).

REFERENCES

Abbey, S.
1977: Studies in 'standard samples' for use in the general analysis of silicate rocks and minerals, Part 5; 1977 Edition of 'Usable' Values; Geological Survey of Canada, Paper 77-34, 31 p.

Barr, S. M.
1982: Geochemistry of granitoid plutons of Cape Breton Island, Nova Scotia; in Uranium in Granites, ed. Y. T. Maurice; Geological Survey Canada, Paper 81-23, p. 55-59.

Barr, S. M., O'Reilly, G. A. and O'Beirne, A. M.
1979: Geochemistry of granitoid plutons of Cape Breton Island; in Mineral Resources Division, Report of Activities, 1978; Nova Scotia Department of Mines and Energy, Report 79-1, p. 109-141.

1982: Geology and geochemistry of selected granitoid plutons of Cape Breton Island; Nova Scotia Department of Mines and Energy, Paper 82-1, 176 p.

Barr, S. M. and Setter, J. R. D.
1981: Plutonic rocks of the Boisdale Hills, central Cape Breton Island; in Mineral Resources Division, Report of Activities, 1980; Nova Scotia Department of Mines and Energy, Report 81-1, p. 123-130.

Bell, W. A. and Goranson, E. A.
1938: Bras d'Or sheet; Canada Department of Mines and Resources, Map 359A.

Blanchard, M. C.
1982: Geochemistry and petrogenesis of the Fisset Brook Formation, western Cape Breton Island, Nova Scotia; M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia; Nova Scotia Department of Mines and Energy, Thesis 493, 198 p.

Cawthorne, R. G., Strong, D. F. and Brown, P. A.
1976: Origin of corundum-normative intrusive and extrusive magmas; Nature, v. 259, p. 102-104.

Chappell, B. W. and White, A. J. R.
1974: Two contrasting granite types; Pacific Geology, v. 8, p. 173-174.

Chatterjee, A. K.
1977: Tungsten mineralization in the carbonate rocks of the George River Group, Cape Breton Island, Nova Scotia; Nova Scotia Department of Mines, Paper 77-7, 26 p.

1983: Metallogenic map of the Province of Nova Scotia; Nova Scotia

Department of Mines and Energy, Scale 1:500 000.

Chatterjee, A. K., Forgeron, S., Hudgins, A., Isenor, G., McNabb, B., Miller, C., Oldale, H. R., Patterson, J. M. and Stewart, E.
1980: Trip 6: Mineral deposits and mineralogenic provinces of Nova Scotia; Geological Association of Canada and Mineralogical Association of Canada Guidebook, Halifax, 1980.

Cormier, R. F.
1972: Radiometric ages of granitic rocks, Cape Breton Island, Nova Scotia; Canadian Journal of Earth Sciences, v. 9, p. 1074-1086.

Deer, W. A., Howie, R. A. and Zussman, J.
1966: An Introduction to the Rock-Forming Minerals; Longmans and Green, London, 528 p.

El Bouseily, A. M. and El Sokkary, A. A.
1975: The relation betwen Rb, Ba, and Sr in granitic rocks; Chemical Geology, v. 16, p. 207-219.

Fairbairn, H. W., Hurley, P. M., Pinson, W. H., Jr. and Cormier, R. F.
1960: Age of the granitic rocks of Nova Scotia; Geological Society of America Bulletin, v. 71, p. 399-414.

Felderhof, G. W.
1978: Barite, celestite and fluorite in Nova Scotia; Nova Scotia Department of Mines, Bulletin 4, 463 p.

Giles, P. S.
1982: Sydney Basin project; in Program and Summaries, Sixth Annual Open House and Review of Activities; Nova Scotia Department of Mines and Energy, Information Series No. 5, p. 19-23.

1983: Sydney Basin project; in Mines and Minerals Branch, Report of Activities, 1982; Nova Scotia Department of Mines and Energy, Report 83-1, p. 57-70.

Gribble, C. D.
1969: Distribution of elements in igneous rocks of the normal calc-alkaline sequence; Scottish Journal of Geology, v. 5, p. 322-327.

Halliday, A. N., Stephens, W. E. and Harmon, R. S.
1981: Isotopic and chemical constraints on the development of peraluminous Caledonian and Acadian granites; Canadian Mineralogist, v. 19, p. 205-216.

Helmstaedt, H. and Tella, S.
1972: Structural history of pre-Carboniferous rocks in parts of eastern Cape Breton Island; Geological Survey of Canada, Paper 72-1, p. 7-10.

1973: Pre-Carboniferous structural history of S. E. Cape Breton Island, Nova Scotia; Maritime Sediments, v. 9, p. 88-99.

Hollister, V. F., Potter, R. R. and Barker, A. L.
1974: Porphyry-type deposits of the Appalachian Orogen; Economic Geology, v. 69, p. 618-629.

Hughes, C. J.
1982: Igneous Petrology; Elsevier Scientific Publishing Company, Amsterdam, 551 p.

Hutchinson, R. D.
1952: The stratigraphy and trilobite faunas of the Cambrian sedimentary rocks of Cape Breton Island, Nova Scotia; Geological Survey of Canada, Memoir 263, 124 p.

Irvine, T. N. and Baragar, W. R. A.
1971: A guide to the chemical classification of the common volcanic rocks; Canadian Journal of Earth Sciences, v. 8, p. 523-548.

Kelley, D. G.
1967: Baddeck and Whycocomagh map-areas; Geological Survey of Canada, Memoir 351, 65 p.

Keppie, J. D. (Compiler)
1979: Geological map of the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Scale 1:500 000.

Keppie, J. D.
1982a: Tectonic map of the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Scale 1:500 000.

1982b: The Minas Geofracture; in Major Structural Zones and Faults of the Northern Appalachians, eds. P. St.-Julien and J. Béland; Geological Association of Canada, Special Paper 24, p. 263-280.

Keppie, J. D. and Dostal, J.
1980: Paleozoic volcanic rocks of Nova Scotia; in Proceedings: "The Caledonides in the U.S.A." International Geological Correlation Program, Project 27: Caledonide Orogen; Department of Geological Science, Virginia Polytechnic Institute and State University, Memoir no. 2, p. 249-256.

Keppie, J. D., Dostal, J. and Murphy, J. B.
1979: Petrology of the Late Precambrian Fourchu Group in the Louisbourg

area, Cape Breton Island; Nova Scotia Department of Mines and Energy, Paper 79-1, 18 p.

Keppie, J. D. and Smith, P. K. (Compilers)
1978: Compilation of isotopic age data of Nova Scotia; Nova Scotia Department of Mines, Report 78-4, 54 p.

Kirkham, R. V. and Soregaroli, A. E.
1975: Preliminary assessment of porphyry deposits in the Canadian Appalachians; Geological Survey of Canada, Paper 75-1, Pt. A, p. 249-251.

Leake, B. E.
1978: Nomenclature of amphiboles; Canadian Mineralogist, v. 16, p. 501-520.

Leterrier, J., Maury, R. C., Thonon, P., Girard, D. and Marchal, M.
1982: Clinopyroxene composition as a method of identification of magmatic affinities of paleo-volcanic series; Earth and Planetary Science Letters, v. 59, p. 139-154.

Milligan, G. C.
1970: The geology of the George River Series, Cape Breton; Nova Scotia Department of Mines, Memoir 7, 111 p.

O'Reilly, G. A.
1977: Field relations and mineral potential of the granitoid rocks of southeast Cape Breton Island; in Mineral Resources Division, Report of Activities, 1976; Nova Scotia Department of Mines, Report 77-1, p. 81-87.

Pitcher, W. S.
1979: The nature, ascent, and emplacement of granitic magmas; Geological Society (London) Journal, v. 136, p. 627-662.

Plimer, I. R. and Elliott, S. M.
1979: The use of Rb/Sr ratios as a guide to mineralization; Journal of Geochemical Exploration, v. 12, p. 21-34.

Pollock, D. W. and Riddell, J. E.
1979: Geology of the Coxheath Hills area, Cape Breton, Nova Scotia; Geological Association of Canada/Mineralogical Association of Canada, Program with Abstracts, v. 4, p. 72.

Poole, W. H.
1980: Rb-Sr age of Shunacadie Pluton, central Cape Breton Island, Nova Scotia; in Current Research, Part C; Geological Survey of Canada, Paper 80-1C, p. 165-169.

Setter, J. R. D.
1981: Geology of the Long Island Pluton, Cape Breton Island, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia; Nova Scotia Department of Mines and Energy, Thesis 466, 173 p.

Smith, T. E., and Turek, A.
1976: Tin-bearing potential of some Devonian granitic rocks in SW Nova Scotia; Mineralium Deposita, v. 11, p. 234-245.

Spry, A.
1974: Metamorphic Textures; Pergamon Press, New York, 350 p.

Stemprok, M.
1979: Mineralized granites and their origin; Episodes, v. 1979, p. 20-24.

Stevens, R. D., Delabio, R. N. and Lachance, G. R.
1982: Age determinations and geological studies, K-Ar isotopic ages, report 15; Geological Survey of Canada, Paper 81-2, 46 p.

Streckeisen, A.
1976: To each plutonic rock its proper name; Earth Science Reviews, v. 12, p. 1-33.

Strong, D. F.
1981: Ore deposit models-5. A model for granophile mineral deposits; Geoscience Canada, v. 8, p. 155-161.

Thornton, C.P. and Tuttle, O. F.
1960: Chemistry of igneous rocks, 1. differentiation index; American Journal of Science, v. 258, p. 664-684.

Tischendorf, G.
1977: Geochemical and petrographic characteristics of silicic magmatic rocks associated with rare-element mineralization; in Metallization Associated with Acid Magmatism, eds. M. Stemprok, L. Brunol, and G. Tischendorf; Geological Survey, Prague, v. 2, p. 41-96.

Vinogradov, A.P.
1962: The average content of chemical elements in the main types of igneous rocks of the Earth; Geochemistry, p. 164.

Wanless, R. K., Stevens, R. D., Lachance, G. R. and Edmonds, C. M.
1968: Age determinations and geological studies, K-Ar isotopic ages, report 8; Geological Survey of Canada, Paper 67-2A, 141 p.

Weeks, L. J.
1954: Southeast Cape Breton Island, Nova Scotia; Geological Survey of Canada, Memoir 277, 122 p.

Winkler, H. G. F.
1976: Petrogenesis of Metamorphic Rocks, 4th Edition; Springer-Verlag, New York, 334 p.

APPENDIX A

PETROGRAPHIC TABLES

APPENDIX A
PETROGRAPHIC TABLES
KEY TO ABBREVIATIONS AND SYMBOLS

Major Minerals

Q Quartz
Ks K-feldspar
Pl Plagioclase
Bi Biotite
Hb Hornblende
Py Pyroxene

Accessory Minerals

O Opaques
A Apatite
S Sphene
Z Zircon

Symbols:
0 = normal abundance
X = more abundant than usual

Rock name follows Streckeisen (1976)

Ks Column

Identity of K-feldspar (based on 2V, twinning)
M Microcline
O Orthoclase
P Perthite

Plagioclase Composition Column

Gives estimated maximum An content (determined by Michel-Levy, combined Carlsbad-albite, or perpendicular to "a" crystallographic axis method).

Grain Size, Texture Column

f.g. fine grained
m.g. medium grained
c.g. coarse grained

Allot. Allotriomorphic
Hyp. Hypidiomorphic

Gran. Equigranular
Inequig. Inequigranular
Porph. Porphyritic
Intergran. Intergranular

Alteration

s = slight, m = moderate, i = intense

C Carbonate
Cl Chlorite (±secondary sphene, rutile)
E Epidote
H Hematite
S Saussurite (includes f.g. albite, carbonate, sericite, clay, epidote, etc., replacing plagioclase)
Sc Sericite

PLUTON: Shunacadie **ROCK UNIT: Biotite Granodiorite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1209	Granodiorite	28	12	48	11	1	-	PM	Zoned -	0	0	0	-	m.g. Allot. Gran.	m	i			m		Carbonate veinlets abundant
K2-1500	Granodiorite	24	9	54	13	-	-	M	Zoned -	0	0	-	0	m.g. Hyp. Gran.		i			i		Interstitial microcline; no biotite left. All minerals exhibit deformation features
K2-1502	Granodiorite	25	11	48	16	-	-	M	Zoned -	0	0	-	0	m.g. Hyp. Gran.		m	m		i		Same features as 1500 but biotite is less altered
K2-1503	Granodiorite	27	14	43	16	-	-	PM	Zoned Rim An7	0	0	0	0	m.g. Hyp. Gran.	s	i	m		i		More magmatic sphene than above
K2-1504	Monzogranite	27	24	39	10	-	-	PM	Zoned -	0	0	-	0	f.g.-m.g. Allot. Gran.		m	s		m		Similar to 1502 with more microcline and less biotite
K2-1505	Granodiorite	29	13	49	9	-	-	PM	Zoned Core An27	0	0	0	-	m.g. Allot. Gran.		s	s		s		Less altered than most. Normal and reverse zoning in plagioclase
K2-1509	Granodiorite	28	10	49	13	-	-	PM	Zoned -	0	0	-	-	f.g.-m.g. Hyp. Gran.		i	s		i		Like 1500
K2-1511	Granodiorite	29	8	48	14	1	-	PM	Zoned -	0	0	0	0	m.g. Hyp. Gran.		m	m		i		Minor green amphibole. Coarser biotite than most samples
K2-1512	Granodiorite	30	10	46	14	-	-	M	Zoned Core An26	0	0	0	0	m.g. Hyp. Gran.		m	m		m		Less altered than most
K2-1514	Granodiorite	27	13	47	13	-	-	M	Zoned	0	0	-	-	m.g. Hyp. Gran.	s	i	m		m		1 grain of tourmaline(?)
K2-1517	Granodiorite	25	11	50	14	-	-	M	Zoned	0	0	0	-	m.g.-c.g. Hyp. Gran.		i	m		i		Coarse euhedral sphene
F15-1523	Granodiorite	24	18	44	14	<1	-	PM	Zoned Core An30	0	0	0	-	m.g. Hyp. Gran.		s	m		m		More poikilitic, interstitial microcline than most. Minor amphibole

(continued)

PLUTON: Shunacadie **ROCK UNIT: Biotite Granodiorite (continued)**

F15-1527	Granodiorite	30	12	45	13	-	-	M	Zoned Core An35	0	X	-	-	m.g. Hyp. Gran.		i			m		No cross-hatched twinning in microcline
F15-1529	Monzogranite	32	21	33	14	-	-	M	Zoned Core An30	0	0	-	-	m.g. Allot. Gran.		m			i		Zoning in plagioclase less well developed
F15-1539	Granodiorite	28	10	47	15	<1	-	M?	Zoned Core An28	0	-	-	-	f.g.-m.g. Allot. Gran.		s			s		Less altered than most. Minor green amphibole clusters
F15-1545	Monzogranite	28	19	35	10	8	-	PO?	Zoned Core An30	0	0	-	-	m.g. Allot. Gran.	m	m			m		K-feldspar has low 2v. Green amphibole is abundant
F15-1546	Granodiorite	21	12	56	8	3	-	PO?	Zoned Core An30	0	X	0	-	m.g. Allot. Gran.		s			s		K-feldspar has low 2v.
F15-1549	Granodiorite	24	19	42	15	-	-	PM	Zoned Core An28	0	X	0	-	m.g. Allot. Gran.		m			s		Minor myrmekite
F15-1556	Monzogranite	25	25	35	9	6	-	PO?	Zoned Core An30	0	0	0	0	m.g. Allot. Gran.		i			i		Like 1545
F15-1564	Granodiorite	21	9	60	10	-	-	PO?	Zoned Core An22	0	0	-	-	m.g. Allot. Gran.		i	s		m		No cross-hatched twinning in K-feldspar
K2-1584	Granodiorite	27	8	51	11	3	-	PO?	Zoned Core An25	0	0	0	-	m.g. Hyp. Gran.		m			s		No cross-hatched twinning in K-feldspar
K2-1586	Granodiorite	20	13	51	16	<1	-	M	-	0	-	-	-	m.g.-c.g. Hyp. Gran.	m	i			i		Abundant carbonate in veinlets and replacing plagioclase

PLUTON: Shunacadie **ROCK UNIT: Granite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1470	Monzogranite	26	28	40	2	4	-	PM	Zoned 0-20	0	X	0	-	m.g.-c.g. Allot. Gra		i				m	Albitic rims on altered plagioclase cores
K2-1583	Monzogranite	24	26	44	4	2	-	PM	Zoned 0-25	0	0	0	-	m.g. Allot. Gran.		i				m	More deformed than 1470

PLUTON: Shunacadie **ROCK UNIT: Leucogranite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K2-1518	Monzogranite	28	37	34	1	-	-	PM	<10	0	-	-	-	c.g. Allot. Gran.		i		s		m	Albitic rims on plagioclase
F15-1547	Syenogranite	38	44	17	1	-	-	PM	20	0	0	-	-	m.g.-c.g. Allot. Gran.		i				m	Moderate deformation

PLUTON: Shubenacadie **ROCK UNIT: Dioritic Rocks**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
F-1570	Monzodiorite	2	8	50	8	27	5	?	55	0	0	0	0	m.g. Hyp. Gran.		s				s	Very fresh

PLUTON: Boisdale Hills **ROCK UNIT: Dioritic Rocks**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1043	Diorite	0	0	60	-	40	-	-	?	0	0	-	-	m.g. Inequi.			s		i	i	Abundant actinolite
K1-1057	Diorite	2	0	64	2	32	-	-	?	0	0	0	-	m.g. Hyp. Gran.			s		i	i	Abundant actinolite
K1-1083	Diorite	2	0	68	5	25	-	-	?	0	?	?	-	m.g. Intergran.			s		i	i	Abundant actinolite
K1-1215	Tonalite	25	2	38	5	30	-	-	50	0	-	-	-	f.g. Intergran.		m	s		s		Relatively fresh
K1-1253	Quartz Diorite	4	1	57	<5	33	2	-	≈50	0	0	0	0	m.g. Hyp. Gran.		i			m	m	Poikilitic amphibole
K1-1365	Diorite	2	2	61	7	28	-	-	≈50	0	0	?	?	f.g. Intergran.		i			i		
K1-1396	Quartz Diorite	4	1	60	4	30	1	-	≈55	0	0	?	?	m.g. Hyp. Gran.		i			i		
K1-1436	Diorite	2	0	58	9	31	2	-	≈60	0	0	?	?	m.g. Hyp. Gran.		s			i		Poikilitic amphibole
F15-1591	Quartz Diorite	8	5	55	10	23	-	?	≈50	0	0	0	0	m.g. Intergran.		s			m	m	Relatively fresh
F15-1598	Quartz Diorite	10	5	42	5	38	-	?	≈50	0	0	0	0	m.g. Intergran.		m			i	i	

PLUTON: Boisdale Hills **ROCK UNIT: Hornblende Granodiorite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
F15-1537	Granodiorite	31	13	40	6	10	-	PM	Zoned ≈40	0	0	0	-	m.g. Hyp. Gran.		s	s		m	m	K-feldspar and quartz are interstitial and poikilitic
F15-1551	Granodiorite	32	13	37	8	10	-	?	?	0	0	?	?	m.g. Hyp. Gran.		i	i	m	i	i	K-feldspar and quartz are interstitial and poikilitic

PLUTON: Boisdale Hills **ROCK UNIT: Biotite Hornblende Granodiorite***

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1008	Granodiorite	28	13	48	6	5	-	PM	Zoned 45	0	0	0	-	m.g. Hyp. Inequig.		m	m		m		
K1-1146	Tonalite	20	6	55	7	12	-	PM	Zoned ≈40	0	0	0	-	m.g. Hyp. Inequig.		s	s		m		
K1-1199	Tonalite	19	6	50	10	15	-	?	≈40	0	0	0	-	m.g. Hyp. Inequig.		m	m		m		
K1-1212	Granodiorite	28	9	50	8	5	-	?	?	0	0	?	-	m.g. Hyp. Inequig.		i			m		
K1-1248	Granodiorite	19	12	50	7	12	-	PM	45	0	0	0	0	m.g. Hyp. Inequig.		m	s		s		Minor myrmekite
K1-1276	Granodiorite	24	17	41	8	10	-	P	45	0	0	0	0	m.g. Hyp. Inequig.		s	s		s		
K1-1350	Granodiorite	18	7	52	10	13	-	?	?	0	0	0	-	m.g. Hyp. Inequig.		m	s		i		
K1-1354	Tonalite	19	6	60	7	8	-	PM	25-45	0	0	?	?	m.g. Hyp. Inequig.		s	s		s		Relatively fresh
K1-1461	Granodiorite	28	10	45	8	9	-	PM	40	0	0	0	-	m.g. Hyp. Inequig.		s	s		m		Deformed
F15-1541	Granodiorite	32	8	43	9	8	-	PM	40	0	0	0	0	m.g. Hyp. Inequig.		s	s		s		
F15-1543	Granodiorite	18	7	49	12	15	-	PM	40	0	0	0	0	m.g. Hyp. Inequig.		s	s		m	m	Minor myrmekite
K2-1581	Granodiorite	26	20	37	12	6	-	PM	?	0	0	0	?	m.g. Hyp. Inequig.	s	m	m		i	m	
F15-1602	Granodiorite	28	11	41	12	8	-	?	40	0	0	?	?	m.g. Hyp. Inequig.	s	i	m		m	m	

*All contain strongly zoned plagioclase. K-feldspar and quartz are interstitial and poikilitic.

PLUTON: Boisdale Hills **ROCK UNIT: Biotite Granodiorite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1013	Granodiorite	20	11	53	16	-	-	?	≈25	O	X	-	-	m.g. Allot. Gran.	s	i	s		m		Deformed
K1-1085	Granodiorite	28	15	45	8	4	-	?	≈40	O	X	-	-	m.g. Hyp. Inequig		i	m		m		Less hbld. but otherwise similar to biotite hbld. granodiorite
K1-1224	Monzogranite	30	25	40	5	-	-	PM	≈40	O	O		O	m.g. Allot. Gran.		m	s		m		
K1-1296	Granodiorite	25	10	50	10	5	-	PM	30	O	-	-	-	m.g. Allot. Inequig.		m	s		m	m	Like 1085
K1-1356	Granodiorite	36	19	40	6	-	-	PM		O	O		O	m.g. Allot. Gran.		s	s		s		

PLUTON: Boisdale Hills **ROCK UNIT: Syenogranite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1050	Syenogranite	39	42	18	<1	-	-	O	?	O	-	-	-	m.g. Granophyric		i	i			s	Largely granophyre
K1-1053	Syenogranite	35	48	16	<1	-	-	O	O-25	O	O	-	-	m.g. Granophyric		i	i			s	Largely granophyre
K1-1059	Syenogranite	25	52	22	<1	-	-	O	Ab?	O	-	-	-	m.g. Granophyric		i	i			s	Largely granophyre
K1-1103	Syenogranite	42	43	15	<1	-	-	O	Ab?	O	-	-	-	m.g. Granophyric		i	i			s	Largely granophyre
K1-1319	Syenogranite	40	45	15	<1	-	-	?	?	O	-	-	-	Cataclastic	s	i	i			s	Cataclased

PLUTON: Boisdale Hills **ROCK UNIT: Microgranite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1399	Monzogranite	25	20	40	7	8	-	?	Zoned ≈30	O	O	-	-	f.g. Hyp. Inequig.		m	m		m		Interstitial subgranophyric quartz and K-feldspar
K1-1449	Monzogranite	30	35	32	3	-	-	?	Zoned ≈40	O	O	O	-	f.g. Hyp. Inequig.		m	i		m		f.g. dioritic xenoliths
K1-1456	Monzogranite	30	35	30	5	-	-	PO	?	O	-	-	-	m.g. Allot. Gran.		m	i		m		Pethitic rims on plagioclase

PLUTON: Boisdale Hills **ROCK UNIT: Leucogranite**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
K1-1252	Syenogranite	35	54	10	1	-	-	P	O-5	O	-	-	-	m.g. Allot. Gran.		i	m	m		s	Strongly perthitic K-felspar

PLUTON: Spruce Brook **ROCK UNIT: Not Subdivided**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
F16-1577	Tonalite	36	6	46	-12-		-	?	25?	0	0	-	-	Cataclastic	m	i	m		m		Highly cataclased
K2-1578	Granite	28	24	33	15	-	-	M	25	0	0	0	-	Cataclastic		i	i		m		Highly cataclased
K1-1594	Quartz Diorite	5	0	50	5	40	-	-	55	0	-	-	-	m.g. Hyp. Gran.		s	m		i	m	Abundant actinolite
K1-1603	Tonalite	36	?0	54	10	0	-	-	40	0	X	-	-	m.g. Allot. Gran.	m	i	m		i	s	Deformed

PLUTON: Coxheath **ROCK UNIT: Not Subdivided**

Sample Number	Rock Name	Major Minerals						Ks	Plag. Comp. (%An)	Accessories				Grain Size, Texture	Alteration						Comments
		Q	Ks	Pl	Bi	Hb	Py			O	A	S	Z		C	Cl	E	H	S	Sc	
CH-4	Diorite	3	3	64	5	25	-	?	60	0	0	0	-	m.g. Hyp. Gran.		m			m		
CH-5	Granodiorite	30	16	44	10	-	-	0?	25	0	-	-	-	c.g. Allot. Gran.	m	i	s		m		Deformed
CH-7	Monzogranite	30	34	32	4	-	-	P0	<25	0	0	-	-	f.g.-m.g. Allot. Gran.		i			m		Plagioclase phenocrysts with albite rims
CH-8	Monzogranite	36	23	36	5	-	-	P0	<25	0	0	0	-	m.g. Allot. Gran.	s	i	m		m		
CH-12	Quartz Monzodiorite	8	10	58	10	14		?	?	0	0	-	-	m.g. Hyp. Gran.		i	m		m		Interstitial quartz and K-feldspar
CH-20	Monzogranite	20	28	50	2	-	-	?	?	X	-	-	-	m.g. Porph. Intergran.	m	i			s	s	Plagioclase phenocrysts. Spherulitic and granophyric patches in groundmass
CH-22	Granodiorite	18	21	40	12	9	-	P0	30	0	0	0	0	m.g. Hyp. Gran.		s	s		m		Interstitial poikilitic quartz and K-feldspar

APPENDIX B

COMPILATION OF MAJOR AND TRACE ELEMENT ANALYSES AND CIPW NORMATIVE MINERALOGIES

PLUTON: SHUNACADIE

ROCK UNIT: BIOTITE GRANODIORITE n=22

SAMPLE	1209	1500	1502	1503	1504	1505	1509
MAJOR ELEMENTS (wt. %)							
SiO_2	68.4	68.2	65.3	66.5	67.3	69.2	68.2
TiO_2	0.43	0.51	0.52	0.55	0.51	0.52	0.49
Al_2O_3	15.2	15.9	16.5	15.3	15.3	15.4	15.7
Fe_2O_3	3.4*	1.4	1.5	1.3	1.4	1.3	1.2
FeO	-	2.1	2.1	2.2	2.1	2.1	2.5
MnO	0.06	0.08	0.09	0.08	0.07	0.08	0.10
MgO	1.4	1.5	1.5	1.8	1.4	1.2	1.6
CaO	2.4	2.6	3.1	2.9	2.6	3.0	2.6
Na_2O	3.8	3.6	4.0	3.9	3.9	4.0	3.9
K_2O	2.1	2.3	2.6	2.3	2.4	2.3	2.4
P_2O_5	0.10	0.10	0.10	0.11	0.11	0.11	0.10
LOI	2.6	1.7	1.3	1.6	1.2	0.70	1.7
Total Oxides	99.9	100.0	98.6	98.5	98.3	99.9	100.5
NORMATIVE MINERALOGY (wt. %)							
Quartz	34.1	30.5	23.5	26.3	28.4	28.8	27.7
Corundum	2.4	3.0	1.9	1.5	2.0	1.3	2.2
Orthoclase	12.4	13.8	15.8	14.3	14.7	13.5	14.4
Albite	33.2	31.2	34.7	33.6	33.5	34.2	33.4
Anorthite	12.3	12.4	15.0	14.2	12.6	14.0	12.5
Diopside	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hypersthene	0.15	5.8	5.9	6.9	5.6	5.2	4.0
Magnetite	3.4	2.1	2.2	2.0	2.0	1.9	1.8
Ilmenite	0.82	1.0	1.0	1.1	1.0	1.0	0.9
Apatite	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Differentiation Index	79.7	75.5	73.9	74.2	76.6	76.4	75.5
TRACE ELEMENTS (ppm)							
Ba	255	320	395	540	335	320	415
Cu	14	37	20	18	29	25	12
F	310	310	380	320	360	280	290
Mo	2	3	1	2	1	1	1
Pb	5	3	12	2	2	12	2
Rb	77	71	85	57	80	80	76
Sn	2.6	3.6	2.4	3.1	2.5	2.1	2.7
Sr	130	149	117	190	140	160	200
U	2.2	3.2	2.9	1.5	2.5	1.9	3.6
Zn	48	107	47	50	52	53	52

(continued)

*Total iron expressed as Fe_2O_3

PLUTON: SHUNACADIE

ROCK UNIT: BIOTITE GRANODIORITE (continued) n=22

SAMPLE	1511	1512	1514	1517	1523	1527	1529
MAJOR ELEMENTS (wt. %)							
SiO_2	67.3	68.2	68.0	68.4	66.4	67.3	66.7
TiO_2	0.54	0.54	0.41	0.50	0.49	0.53	0.43
Al_2O_3	15.4	15.7	15.5	15.5	15.4	16.2	15.9
Fe_2O_3	1.6	1.3	1.3	1.1	1.8	2.0	2.0
FeO	2.2	2.1	2.1	2.3	2.1	2.0	2.1
MnO	0.10	0.08	0.07	0.08	0.10	0.09	0.07
MgO	1.5	1.6	1.5	1.7	1.3	1.4	1.3
CaO	3.4	3.0	2.5	1.9	3.6	3.1	1.5
Na_2O	3.7	3.9	3.9	3.9	3.3	3.5	3.7
K_2O	2.2	2.5	2.1	2.5	3.4	2.6	3.4
P_2O_5	0.11	0.11	0.09	0.09	0.14	0.16	0.13
LOI	1.2	1.2	1.5	1.6	1.0	1.6	1.8
Total Oxides	99.3	100.2	99.0	99.6	99.0	101.5	99.0
NORMATIVE MINERALOGY (wt. %)							
Quartz	27.8	26.8	29.7	29.2	25.1	28.5	27.9
Corundum	1.1	1.4	2.4	3.2	0.3	2.5	4.0
Orthoclase	13.5	15.0	12.7	15.2	20.2	15.5	20.6
Albite	31.8	33.3	33.9	33.7	28.2	30.0	31.8
Anorthite	16.3	14.3	12.3	9.0	17.2	14.3	6.6
Diopside	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hypersthene	6.1	6.1	5.9	6.9	5.2	5.0	5.2
Magnetite	2.3	1.9	2.1	1.6	2.6	2.9	2.8
Ilmenite	1.0	1.0	0.8	1.0	1.0	1.0	0.8
Apatite	0.2	0.2	0.2	0.2	0.3	0.4	0.3
Differentiation Index	73.1	75.1	76.3	78.1	73.5	74.0	80.3
TRACE ELEMENTS (ppm)							
Ba	460	400	310	420	545	540	550
Cu	25	20	14	11	30	38	13
F	290	340	330	320	290	360	290
Mo	1	1	1	1	1	1	1
Pb	5	6	4	2	24	20	3
Rb	72	89	75	103	93	85	106
Sn	3.1	2.1	3.3	2.9	2.1	2.6	3.2
Sr	195	145	138	160	233	265	218
U	2.4	2.7	2.2	1.8	1.6	1.6	2.7
Zn	59	41	46	52	74	81	67

(continued)

PLUTON: SHUNACADIE

ROCK UNIT: BIOTITE GRANODIORITE (continued) n=22

SAMPLE	1539	1545	1546	1549	1556	1564	1584
MAJOR ELEMENTS (wt. %)							
SiO_2	67.7	69.7	67.4	64.3	67.4	68.5	67.7
TiO_2	0.50	0.50	0.41	0.51	0.41	0.41	0.57
Al_2O_3	15.5	13.1	15.5	16.0	14.7	15.9	16.1
Fe_2O_3	0.2	1.1	1.8	1.6	2.0	1.3	1.8
FeO	3.1	3.7	2.0	2.3	1.9	1.8	2.0
MnO	0.09	0.11	0.09	0.10	0.10	0.07	0.09
MgO	1.6	0.8	1.3	1.8	1.5	1.5	1.7
CaO	3.3	2.3	3.2	3.0	3.2	3.1	3.0
Na_2O	4.0	3.7	3.7	3.6	3.2	4.1	3.9
K_2O	2.1	2.0	2.8	3.0	3.1	1.4	2.5
P_2O_5	0.13	0.11	0.11	0.15	0.12	0.09	0.10
LOI	0.8	1.8	1.0	1.3	1.3	1.2	0.9
Total Oxides	99.0	98.9	99.3	97.7	98.9	99.4	100.4
NORMATIVE MINERALOGY (wt. %)							
Quartz	25.8	33.7	26.6	23.3	28.8	30.3	26.8
Corundum	1.1	1.0	0.9	2.0	0.8	2.1	1.9
Orthoclase	12.6	11.9	16.6	18.3	19.4	8.6	14.6
Albite	34.3	31.8	32.0	31.6	26.5	35.5	32.7
Anorthite	15.8	11.1	15.4	14.2	15.2	15.3	14.4
Diopside	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hypersthene	8.9	7.5	5.0	7.0	5.2	5.5	5.8
Magnetite	0.3	1.7	2.5	2.3	3.0	1.8	2.5
Ilmenite	1.0	1.0	0.8	0.7	0.8	0.8	1.1
Apatite	0.3	0.2	0.2	0.4	0.3	0.2	0.2
Differentiation Index	72.7	77.5	75.2	73.2	74.7	74.3	74.2
TRACE ELEMENTS (ppm)							
Ba	300	595	480	510	495	310	480
Cu	19	12	14	37	7	1	25
F	330	290	360	330	390	330	340
Mo	1	2	1	1	1	2	2
Pb	10	12	32	11	12	7	4
Rb	77	54	63	76	81	53	66
Sn	1.9	2.8	2.9	2.6	2.3	3.1	2.2
Sr	195	220	218	342	242	193	235
U	2.3	2.0	2	2.6	2.8	14	1.8
Zn	61	91	84	99	56	46	50

(continued)

PLUTON: SHUNACADIE

ROCK UNIT: BIOTITE GRANODIORITE (continued) n=22

SAMPLE	**1586**
MAJOR ELEMENTS (wt. %)	
SiO_2	67.5
TiO_2	0.45
Al_2O_3	15.1
Fe_2O_3	1.7
FeO	1.6
MnO	0.07
MgO	0.9
CaO	2.4
Na_2O	3.7
K_2O	2.2
P_2O_5	0.11
LOI	3.4
Total Oxides	99.1
NORMATIVE MINERALOGY (wt. %)	
Quartz	32.3
Corundum	2.6
Orthoclase	13.8
Albite	32.3
Anorthite	11.9
Diopside	0.0
Hypersthene	3.5
Magnetite	2.5
Ilmenite	0.9
Apatite	0.2
Differentiation Index	78.4
TRACE ELEMENTS (ppm)	
Ba	380
Cu	18
F	240
Mo	1
Pb	2
Rb	46
Sn	2.6
Sr	190
U	2.1
Zn	30

PLUTON: SHUNACADIE

ROCK UNIT: GRANITE n=2

SAMPLE	**1470**	**1583**
MAJOR ELEMENTS (wt. %)		
SiO_2	73.1	73.0
TiO_2	0.29	0.29
Al_2O_3	12.9	13.3
Fe_2O_3	2.9	1.1
FeO	0.0	1.6
MnO	0.05	0.05
MgO	0.51	0.45
CaO	1.3	0.74
Na_2O	3.3	3.4
K_2O	4.0	4.3
P_2O_5	-	0.08
LOI	0.85	1.17
Total Oxides	99.2	99.6
NORMATIVE MINERALOGY (wt. %)		
Quartz	36.5	34.2
Corundum	0.75	1.9
Orthoclase	24.1	26.0
Albite	28.1	29.5
Anorthite	6.8	3.15
Diopside	0.0	0.0
Hypersthene	0.13	2.9
Magnetite	0.87	1.6
Ilmenite	0.54	0.54
Apatite	0.0	0.19
Differentiation Index	88.7	89.8
TRACE ELEMENTS (ppm)		
Ba	560	520
Cu	5	6
F	510	390
Mo	2	2
Pb	18	8
Rb	155	142
Sn	5.4	4.8
Sr	100	92
U	4.0	2.2
Zn	55	60

PLUTON: SHUNACADIE

ROCK UNIT: LEUCOGRANITE n=2

SAMPLE	1518	1547
MAJOR ELEMENTS (wt. %)		
SiO_2	78.3	76.3
TiO_2	0.04	0.20
Al_2O_3	12.7	11.4
Fe_2O_3	0.66	1.04
FeO	0.39	0.57
MnO	0.10	0.10
MgO	0.30	0.22
CaO	0.37	0.23
Na_2O	3.5	2.5
K_2O	4.2	4.4
P_2O_5	0.03	0.04
LOI	0.48	0.93
Total Oxides	101.1	99.0
NORMATIVE MINERALOGY (wt. %)		
Quartz	40.5	45.8
Corundum	1.6	2.3
Orthoclase	25.8	27.1
Albite	29.2	21.4
Anorthite	1.7	0.9
Diopside	0.0	0.0
Hypersthene	1.1	0.5
Magnetite	0.94	1.3
Ilmenite	0.08	0.39
Apatite	0.02	0.10
Differentiation Index	96.5	94.3
TRACE ELEMENTS (ppm)		
Ba	106	535
Cu	2	2
F	140	240
Mo	4	2
Pb	28	12
Rb	182	168
Sn	2	3
Sr	25	43
U	3	4
Zn	5	11

PLUTON: SHUNACADIE

ROCK UNIT: DIORITE n=1

SAMPLE	1570
MAJOR ELEMENTS (wt. %)	
SiO_2	58.6
TiO_2	0.77
Al_2O_3	15.8
Fe_2O_3	2.3
FeO	5.4
MnO	0.16
MgO	4.5
CaO	7.2
Na_2O	2.8
K_2O	2.1
P_2O_5	0.19
LOI	0.9
Total Oxides	100.7
NORMATIVE MINERALOGY (wt. %)	
Quartz	11.8
Corundum	0.0
Orthoclase	12.3
Albite	23.9
Anorthite	24.4
Diopside	8.3
Hypersthene	14.0
Magnetite	3.4
Ilmenite	1.5
Apatite	0.44
Differentiation Index	48.0
TRACE ELEMENTS (ppm)	
Ba	370
Cu	240
F	320
Mo	1.4
Pb	6
Rb	68
Sn	2.2
Sr	275
U	1.2
Zn	86

PLUTON: BOISDALE HILLS

ROCK UNIT: DIORITIC ROCKS n=10

SAMPLE	1043	1057	1083	1215	1253	1365	1396
MAJOR ELEMENTS (wt. %)							
SiO_2	44.7	52.8	50.8	58.6	46.9	51.3	50.8
TiO_2	0.87	1.8	3.0	0.65	1.1	1.4	0.85
Al_2O_3	20.5	16.8	14.6	17.4	19.9	17.9	18.7
Fe_2O_3	6.0	6.2	2.0	3.0	6.3	3.5	4.5
FeO	5.0	5.2	7.1	4.2	5.7	5.9	4.7
MnO	0.17	0.15	0.20	0.23	0.13	0.16	0.13
MgO	5.4	4.0	6.1	3.3	6.1	4.5	5.0
CaO	10.7	6.4	8.4	6.7	7.1	9.2	6.5
Na_2O	0.44	4.5	4.0	3.6	4.2	3.7	4.1
K_2O	3.3	0.79	1.0	1.2	0.19	0.82	1.7
P_2O_5	0.03	0.15	0.25	0.26	0.19	0.18	0.15
LOI	2.8	1.4	1.6	1.6	2.4	2.4	2.1
Total Oxides	99.9	100.2	99.1	100.7	100.2	100.1	99.2
NORMATIVE MINERALOGY (wt. %)							
Quartz	0.0	5.2	0.0	13.8	0.0	1.4	0.0
Corundum	0.0	0.0	0.0	0.0	0.39	0.0	0.0
Orthoclase	19.8	4.7	6.2	7.0	1.2	1.2	10.4
Albite	3.8	38.8	34.9	30.3	35.9	31.6	35.4
Anorthite	45.8	23.4	19.4	28.3	34.8	30.5	28.5
Diopside	6.8	6.2	17.6	2.8	0.0	2.0	3.0
Hypersthene	11.0	8.9	8.8	11.7	7.1	11.5	11.0
Olivine	2.0	0.0	3.8	0.0	8.8	0.0	2.1
Magnetite	9.0	9.1	2.9	4.3	9.3	5.1	6.8
Ilmenite	1.7	3.4	5.8	1.2	2.1	2.6	1.7
Apatite	0.07	0.35	0.57	0.59	0.45	0.4	0.36
Differentiation Index	23.6	48.7	41.1	51.1	37.1	37.9	45.8
TRACE ELEMENTS (ppm)							
Ba	400	130	275	310	132	250	295
Cu	38	16	31	1	52	8	35
F	290	600	950	290	330	460	290
Mo	1	2	1	1	1	3	2
Pb	2	3	2	12	2	6	2
Rb	224	57	52	38	14	72	59
Sn	0.5	7	3.1	1	2.2	4.5	2
Sr	208	320	495	245	315	220	300
U	0.2	1	0.5	0.4	0.4	3.3	0.7
Zn	73	87	69	99	74	61	92

(continued)

PLUTON: BOISDALE HILLS

ROCK UNIT: DIORITIC ROCKS (continued) n=10

SAMPLE	1436	1591	1598
MAJOR ELEMENTS (wt. %)			
SiO_2	47.9	56.9	56.1
TiO_2	3.0	2.0	0.87
Al_2O_3	14.8	16.3	17.3
Fe_2O_3	5.7	3.1	2.5
FeO	9.8	5.2	4.0
MnO	0.25	0.25	0.15
MgO	5.7	2.8	5.2
CaO	8.6	4.8	6.6
Na_2O	3.4	4.2	4.1
K_2O	0.24	1.9	1.8
P_2O_5	0.17	0.79	0.15
LOI	1.1	0.9	1.8
Total Oxides	100.7	99.1	100.5
NORMATIVE MINERALOGY (wt. %)			
Quartz	0.35	10.1	4.0
Corundum	0.0	0.0	0.0
Orthoclase	1.4	11.5	10.9
Albite	29.2	36.4	35.0
Anorthite	24.3	20.6	23.7
Diopside	14.3	3.2	6.8
Hypersthene	16.2	9.8	13.9
Olivine	0.0	0.0	0.0
Magnetite	8.1	4.7	3.7
Ilmenite	5.6	3.9	1.7
Apatite	0.37	0.0	0.35
Differentiation Index	31.0	57.9	49.9
TRACE ELEMENTS (ppm)			
Ba	115	510	315
Cu	3	4	38
F	340	670	540
Mo	1	3	2
Pb	2	8	7
Rb	14	67	72
Sn	2.3	2.1	1.2
Sr	300	330	288
U	0.4	1.2	0.9
Zn	52	140	124

PLUTON: BOISDALE HILLS

ROCK UNIT: HORNBLENDE GRANODIORITE n=2

SAMPLE	1537	1551
MAJOR ELEMENTS (wt. %)		
SiO_2	66.3	66.5
TiO_2	0.39	0.39
Al_2O_3	15.1	15.5
Fe_2O_3	1.8	1.6
FeO	2.3	2.6
MnO	0.10	0.10
MgO	1.7	2.1
CaO	3.5	3.4
Na_2O	3.3	3.3
K_2O	4.0	2.5
P_2O_5	0.09	0.09
LOI	1.6	1.9
Total Oxides	100.2	100.0
NORMATIVE MINERALOGY (wt. %)		
Quartz	21.6	26.6
Corundum	0.0	1.4
Orthoclase	24.2	15.2
Albite	28.2	28.6
Anorthite	14.6	16.6
Diopside	1.8	0.0
Hypersthene	5.9	8.4
Magnetite	2.6	2.3
Ilmenite	0.75	0.76
Apatite	0.19	0.19
Differentiation Index	74.2	70.4
TRACE ELEMENTS (ppm)		
Ba	345	415
Cu	6	1
F	290	360
Mo	2	2
Pb	8	24
Rb	95	73
Sn	1.4	1.6
Sr	215	245
U	3.8	1.3
Zn	69	106

PLUTON: BOISDALE HILLS

ROCK UNIT: BIOTITE HORNBLENDE GRANODIORITE n=13

SAMPLE	1354	1461	1541	1543	1581	1602
MAJOR ELEMENTS (wt. %)						
SiO_2	63.7	65.0	66.0	59.4	65.3	63.7
TiO_2	0.32	0.39	0.49	0.75	0.54	0.34
Al_2O_3	18.4	16.8	15.7	17.3	16.0	16.2
Fe_2O_3	1.5	2.0	1.8	1.8	2.6	2.1
FeO	2.8	2.5	2.6	4.4	2.3	2.7
MnO	0.06	0.11	0.11	0.12	0.10	0.10
MgO	2.1	2.1	2.2	3.4	2.8	3.0
CaO	5.0	3.9	3.4	5.4	3.0	3.0
Na_2O	3.6	3.8	3.2	3.1	3.2	3.3
K_2O	1.2	1.4	2.5	2.4	2.6	2.4
P_2O_5	0.13	0.09	0.11	0.13	0.09	0.08
LOI	1.0	1.8	1.8	1.8	2.5	2.2
Total Oxides	99.8	99.9	99.9	100.0	101.0	99.1
NORMATIVE MINERALOGY (wt. %)						
Quartz	23.6	25.8	26.8	13.5	26.3	24.7
Corundum	2.5	2.2	1.8	0.0	2.8	3.2
Orthoclase	7.2	8.6	14.8	14.6	15.6	14.4
Albite	30.5	32.4	27.7	26.6	27.3	28.5
Anorthite	24.2	19.4	16.7	26.6	14.6	14.6
Diopside	0.0	0.0	0.0	0.07	0.0	0.0
Hypersthene	8.9	7.8	8.4	14.2	8.4	10.7
Magnetite	2.2	2.9	2.6	2.6	3.9	3.1
Ilmenite	0.62	0.76	0.95	1.5	1.0	0.65
Apatite	0.28	0.19	0.24	0.28	0.19	0.19
Differentiation Index	61.3	66.8	69.3	54.8	69.2	67.6
TRACE ELEMENTS (ppm)						
Ba	240	295	390	335	470	450
Cu	6	3	9	40	17	11
F	420	260	290	560	240	310
Mo	2	2	1	1	3	2
Pb	3	6	12	26	4	2
Rb	59	30	73	85	92	73
Sn	1.8	0.7	1.7	1.9	3.7	1.0
Sr	330	245	245	210	295	233
U	2.2	1.6	1.6	1.0	2.0	1.7
Zn	26	51	90	90	80	79

(continued)

PLUTON: BOISDALE HILLS

ROCK UNIT: BIOTITE HORNBLENDE GRANODIORITE (continued) n=13

SAMPLE	1008	1146	1199	1212	1248	1276	1350
MAJOR ELEMENTS (wt. %)							
SiO_2	65.7	64.1	62.6	69.6	65.0	66.7	65.0
TiO_2	0.42	0.50	0.57	0.34	0.51	0.51	0.64
Al_2O_3	17.1	16.9	16.9	15.2	16.0	16.1	15.9
Fe_2O_3	1.1	2.3	2.6	0.90	2.1	1.1	3.2
FeO	3.0	2.9	3.2	2.7	3.3	3.3	3.3
MnO	0.01	0.10	0.12	0.08	0.11	0.10	0.13
MgO	1.7	2.2	2.5	2.0	2.3	2.4	2.5
CaO	4.9	5.4	5.3	1.7	5.2	5.0	4.2
Na_2O	3.3	3.3	3.3	3.6	3.2	3.3	3.0
K_2O	2.3	1.5	1.4	2.6	2.0	1.4	1.3
P_2O_5	0.10	0.10	0.10	0.09	0.90	0.11	0.24
LOI	1.7	1.0	1.6	2.0	0.0	0.75	1.6
Total Oxides	99.3	100.3	100.2	100.6	100.6	100.9	101.0
NORMATIVE MINERALOGY (wt. %)							
Quartz	23.9	23.6	22.5	31.4	23.4	26.0	29.9
Corundum	0.67	0.37	0.54	3.8	0.0	0.20	2.7
Orthoclase	13.5	8.8	8.2	15.5	11.9	8.3	7.5
Albite	27.7	28.2	28.4	30.5	26.9	28.0	25.6
Anorthite	23.6	26.1	26.0	7.7	23.6	24.3	19.2
Diopside	0.0	0.0	0.0	0.0	1.3	0.0	0.0
Hypersthene	8.0	8.4	9.1	8.9	8.8	10.5	8.7
Magnetite	1.7	3.3	3.9	1.3	3.0	1.6	4.7
Ilmenite	0.78	0.96	1.1	0.64	0.97	0.97	1.2
Apatite	0.23	0.23	0.24	0.21	0.19	0.23	0.56
Differentiation Index	65.0	60.6	59.1	77.4	62.3	62.3	63.0
TRACE ELEMENTS (ppm)							
Ba	350	320	225	415	280	250	205
Cu	11	24	2	41	5	8	13
F	460	400	240	390	370	460	400
Mo	3	2	2	2	2	3	2
Pb	10	8	5	20	8	6	4
Rb	78	61	57	108	68	72	52
Sn	1.2	2.0	1.6	11.0	1.3	4.5	1.7
Sr	268	262	250	175	228	220	270
U	1.7	1.3	1.3	2.6	1.4	3.3	2.0
Zn	49	56	63	48	60	61	68

PLUTON: BOISDALE HILLS

ROCK UNIT: BIOTITE GRANODIORITE n=5

SAMPLE	**1013**	**1085**	**1224**	**1296**	**1356**
MAJOR ELEMENTS (wt. %)					
SiO_2	69.8	65.2	71.4	65.2	71.7
TiO_2	0.42	0.43	0.27	0.42	0.10
Al_2O_3	15.4	16.5	14.9	16.8	14.5
Fe_2O_3	2.0	2.2	1.0	2.1	0.16
FeO	2.1	2.6	1.5	2.4	2.0
MnO	0.08	0.10	0.08	0.10	0.03
MgO	0.40	2.4	1.1	2.2	0.76
CaO	2.9	4.5	2.4	3.7	2.2
Na_2O	3.7	3.5	3.7	3.6	3.4
K_2O	2.1	0.81	2.1	1.7	3.4
P_2O_5	0.12	0.12	0.09	0.09	0.07
LOI	1.8	1.6	1.0	2.5	1.2
Total Oxides	100.8	100.0	99.5	100.8	99.5
NORMATIVE MINERALOGY (wt. %)					
Quartz	33.3	28.1	35.3	26.4	32.3
Corundum	2.0	2.0	2.5	2.6	1.5
Orthoclase	12.8	4.8	12.3	10.1	20.7
Albite	31.5	30.4	32.1	30.9	29.2
Anorthite	13.8	21.6	11.4	18.1	10.5
Diopside	0.0	0.0	0.0	0.0	0.0
Hypersthene	2.6	8.7	4.3	7.8	5.4
Magnetite	3.0	3.3	1.5	3.1	0.22
Ilmenite	0.79	0.81	0.50	0.79	0.19
Apatite	0.26	0.28	0.19	0.21	0.14
Differentiation Index	77.5	63.3	79.6	67.4	82.1
TRACE ELEMENTS (ppm)					
Ba	395	285	468	315	720
Cu	2	1	1	3	19
F	320	290	250	240	260
Mo	2	2	2	2	2
Pb	2	2	4	2	18
Rb	74	45	82	45	78
Sn	1.3	0.9	1.4	1.2	0.8
Sr	210	282	212	240	240
U	1.2	1.5	2.0	2.4	1.2
Zn	56	62	32	52	29

PLUTON: BOISDALE HILLS

ROCK UNIT: SYENOGRANITE n=5

SAMPLE	1050	1053	1059	1103	1319
MAJOR ELEMENTS (wt. %)					
SiO_2	78.0	77.5	76.3	76.7	74.2
TiO_2	0.12	0.15	0.15	0.14	0.25
Al_2O_3	12.8	12.7	13.9	12.5	13.8
Fe_2O_3	0.06	0.05	0.16	0.33	0.34
FeO	0.77	0.68	0.80	0.80	0.90
MnO	0.04	0.04	0.04	0.04	0.03
MgO	0.14	0.20	0.26	0.23	0.23
CaO	0.50	0.57	0.84	0.73	0.31
Na_2O	4.1	3.9	4.2	4.5	4.5
K_2O	3.4	4.3	3.6	3.4	4.6
P_2O_5	0.01	0.03	0.03	0.01	0.03
LOI	<0.1	0.4	0.2	0.2	0.6
Total Oxides	99.9	100.5	100.5	99.6	99.8
NORMATIVE MINERALOGY (wt. %)					
Quartz	39.5	36.2	35.2	35.3	29.5
Corundum	1.6	0.6	1.6	0.1	1.0
Orthoclase	20.3	25.5	21.4	20.4	27.4
Albite	34.4	33.1	35.6	38.2	38.1
Anorthite	2.4	2.6	3.9	3.6	1.4
Diopside	0.0	0.0	0.0	0.0	0.0
Hypersthene	1.5	1.5	1.8	1.6	1.6
Magnetite	0.09	0.07	0.23	0.48	0.50
Ilmenite	0.23	0.29	0.28	0.25	0.48
Apatite	0.02	0.07	0.07	0.02	0.07
Differentiation Index	94.1	94.8	92.2	94.0	95.0
TRACE ELEMENTS (ppm)					
Ba	380	460	415	352	470
Cu	1	1	2	1	3
F	170	190	150	130	240
Mo	1	2	2	2	2
Pb	2	2	10	2	5
Rb	134	184	118	101	126
Sn	3.5	2.9	6.3	6.5	3.5
Sr	70	55	78	110	40
U	3.7	3.5	4.1	2.6	3.4
Zn	30	23	20	18	23

PLUTON: BOISDALE HILLS

ROCK UNIT: MICROGRANITE n=3

SAMPLE	1399	1449	1456
MAJOR ELEMENTS (wt. %)			
SiO_2	68.0	67.4	68.9
TiO_2	0.77	0.59	0.4
Al_2O_3	15.5	15.5	15.3
Fe_2O_3	2.1	2.1	2.0
FeO	3.0	1.9	1.4
MnO	0.11	0.07	0.07
MgO	1.1	1.4	0.55
CaO	2.3	2.8	1.5
Na_2O	5.1	4.7	6.0
K_2O	1.7	2.6	3.2
P_2O_5	0.19	0.16	0.10
LOI	1.1	1.4	1.2
Total Oxides	101.0	100.6	100.7
NORMATIVE MINERALOGY (wt. %)			
Quartz	24.8	22.6	18.4
Corundum	1.6	0.3	0.0
Orthoclase	10.1	15.7	18.7
Albite	43.2	39.8	50.9
Anorthite	10.0	12.8	5.6
Diopside	0.0	0.0	1.1
Hypersthene	5.3	3.3	1.2
Magnetite	3.1	3.1	2.9
Ilmenite	1.5	1.1	0.9
Apatite	0.4	0.4	0.2
Differentiation Index	78.1	78.1	88.1
TRACE ELEMENTS (ppm)			
Ba	390	285	360
Cu	8	9	3.0
F	480	490	360
Mo	2	2	2
Pb	8	6	7
Rb	74	102	99
Sn	2.6	4.3	3.5
Sr	155	142	130
U	2.0	3.1	3.0
Zn	4	65	40

PLUTON: BOISDALE HILLS

ROCK UNIT: LEUCOGRANITE n=1

SAMPLE	1252
MAJOR ELEMENTS (wt. %)	
SiO_2	75.1
TiO_2	0.15
Al_2O_3	13.6
Fe_2O_3	0.55
FeO	0.60
MnO	0.03
MgO	0.10
CaO	0.43
Na_2O	4.4
K_2O	4.2
P_2O_5	0.03
LOI	0.0
Total Oxides	99.5
NORMATIVE MINERALOGY (wt. %)	
Quartz	32.4
Corundum	1.1
Orthoclase	25.0
Albite	37.8
Anorthite	1.9
Diopside	0.0
Hypersthene	0.71
Magnetite	0.80
Ilmenite	0.29
Apatite	0.07
Differentiation Index	95.2
TRACE ELEMENTS (ppm)	
Ba	390
Cu	3
F	210
Mo	2
Pb	6
Rb	150
Sn	5
Sr	46
U	3
Zn	17

PLUTON: SPRUCE BROOK

ROCK UNIT: Not Subdivided **n=4**

SAMPLE	**1577**	**1578**	**1594**	**1603**
MAJOR ELEMENTS (wt. %)				
SiO_2	71.3	70.4	49.8	68.0
TiO_2	0.38	0.45	0.63	0.25
Al_2O_3	14.0	14.1	18.1	15.5
Fe_2O_3	1.5	1.7	3.7	1.4
FeO	1.7	2.1	4.5	1.4
MnO	0.08	0.07	0.22	0.08
MgO	1.3	1.8	7.9	1.0
CaO	1.6	0.91	7.2	1.8
Na_2O	4.1	3.6	2.9	4.5
K_2O	2.2	3.4	1.4	1.9
P_2O_5	0.08	0.12	0.12	0.12
LOI	1.5	1.7	4.2	2.3
Total Oxides	99.7	100.4	100.7	98.3
NORMATIVE MINERALOGY (wt. %)				
Quartz	33.5	32.0	0.0	30.7
Corundum	2.2	3.2	0.0	3.3
Orthoclase	13.4	20.4	8.4	11.5
Albite	35.5	30.6	25.2	39.4
Anorthite	7.4	3.8	33.8	8.5
Diopside	0.0	0.0	1.8	0.0
Hypersthene	4.8	6.4	22.8	3.9
Olivine	0.0	0.0	1.1	0.0
Magnetite	2.2	2.6	5.6	2.1
Ilmenite	0.73	0.85	1.2	0.5
Apatite	0.19	0.28	0.29	0.29
Differentiation Index	82.5	83.0	33.6	81.5
TRACE ELEMENTS (ppm)				
Ba	595	720	520	285
Cu	5	6	56	6
F	310	310	280	260
Mo	4	3	3	2
Pb	2	8	6	2
Rb	68	110	58	48
Sn	3	2	2	1
Sr	200	152	350	330
U	1	3	0.3	1
Zn	46	41	184	56

PLUTON: COXHEATH

ROCK UNIT: Not Subdivided n=7

SAMPLE	CH4	CH5	CH7	CH8	CH12	CH20	CH22
MAJOR ELEMENTS (wt. %)							
SiO_2	55.3	65.8	71.7	69.1	59.4	68.1	65.4
TiO_2	0.84	0.44	0.25	0.38	0.78	0.61	0.57
Al_2O_3	17.7	15.4	14.4	14.7	17.1	15.2	16.1
Fe_2O_3	3.3	1.2	0.93	1.5	2.9	1.5	1.7
FeO	4.1	2.2	0.94	1.5	3.6	1.5	2.2
MnO	0.13	0.05	0.04	0.04	0.13	0.08	0.06
MgO	4.2	1.9	0.71	1.4	3.2	0.99	2.3
CaO	6.7	3.2	1.4	1.6	5.3	1.3	3.1
Na_2O	3.5	4.2	3.9	3.6	3.3	4.4	3.8
K_2O	3.4	1.6	3.6	3.9	2.9	3.5	3.2
P_2O_5	0.24	0.13	0.06	0.09	0.23	0.16	0.14
LOI	1.9	3.3	1.3	1.5	2.5	2.3	1.7
Total Oxides	101.3	99.4	98.6	99.3	101.3	101.1	100.3
NORMATIVE MINERALOGY (wt. %)							
Quartz	5.6	26.2	32.2	28.6	12.8	25.6	21.0
Corundum	0.0	1.4	1.8	2.0	0.0	2.3	1.2
Orthoclase	14.1	9.5	21.4	23.3	17.2	21.3	19.4
Albite	30.4	37.1	33.3	30.9	28.3	38.5	32.5
Anorthite	26.1	15.5	6.9	7.4	23.7	5.3	14.6
Diopside	5.0	0.0	0.0	0.0	1.2	0.0	0.0
Hypersthene	11.9	7.3	2.5	4.5	10.6	3.2	6.8
Magnetite	4.9	1.8	1.4	2.3	4.3	2.3	2.5
Ilmenite	1.6	0.85	0.49	0.74	1.5	1.2	1.1
Apatite	0.57	0.29	0.14	0.19	0.54	0.38	0.31
Differentiation Index	50.0	72.8	86.9	82.8	58.3	85.5	72.9
TRACE ELEMENTS (ppm)							
Ba	550	270	700	800	620	850	760
Cu	60	69	20	950	73	12	34
F	490	310	310	420	450	480	510
Mo	2	6	2	4	3	3	7
Pb	4	5	6	16	20	4	5
Rb	82	67	146	145	127	114	106
Sn	2	1	1	2	2	3	1
Sr	510	402	230	350	500	240	480
U	7	2	3	6	2	4	3
Zn	74	46	19	88	126	52	44

APPENDIX C

ACCURACY AND PRECISION OF ANALYSES

APPENDIX C
ACCURACY AND PRECISION OF ANALYSES

Analyses at Acadia University, Wolfville, were done in duplicate, using international reference samples AGV-1, BCR-1, G-2, GSP-1, JB-1 and JG-1 as standards (Abbey, 1977). Duplicate results were always within 10 per cent (and usually much less) of one another. At the Chemical Laboratory for the Investigation of Minerals (CLIM), Atlantic Industrial Research Institute, Technical University of Nova Scotia, Halifax, Nova Scotia, standard samples SY-2 and SY-3 and internal standard samples CB-1 and CG-1 were included with each sample batch. Results are compiled in Tables C-1 and C-2. Particularly where concentrations are small or near detection limits, considerable scatter is apparent in the data, and it is obvious that major interpretations should not be based on a single sample.

In this study, conclusions are based on patterns shown by groups of samples from each lithogic unit, and such data generally show reasonable internal consistency.

Table C-1. Results for reference samples SY-2 and SY-3

	SY-2			SY-3		
	Recommended*	CLIM A**	CLIM B**	Recommended*	CLIM A**	CLIM B**
%						
FeO	3.55	3.45	3.45	3.56	--	--
P_2O_5	0.44	0.29	0.44	0.54	--	--
ppm						
As	18?	20	18.5	--	--	--
Ba	460	--	--	440	470	420
Cu	4	1	2	17	13	12
F	500	430	430	--	--	--
Mo	--	--	--	--	0.8	0.8
Pb	86	80	84	130	132	132
Rb	220	233	229	210	206	210
Sn	5	--	--	6	6.2	6.7
Sr	270	--	--	300	295	308
Zn	250	254	250	250	252	257

* Recommended values from Abbey (1977)
** CLIM A = K1 samples
CLIM B = all other samples
-- not determined

Table C-2. Results for reference samples CB-1 and CG-1 (internal standards)

	CB-1			CG-1		
	Accepted Average*	CLIM A**	CLIM B**	Accepted Average*	CLIM A**	CLIM B**
%						
FeO	5.97	5.80	5.79	4.38	4.34	4.32
P_2O_5	0.17	0.153	0.15	0.29	0.43	0.29
ppm						
As	6	5	2.8	8.9	8	6.8
Ba	204	190	190	721	--	--
Cu	412	400	421	18	16	20
F	440	260	--	640	--	600
Mo	1.9	1.8	1.8	1.8	--	--
Pb	5	3	2	20	17	16
Rb	22	20	24	122	135	131
Sn	1.3	2	2	3.1	--	--
Sr	178	195	170	202	--	--
Zn	103	104	106	73	75	76

* from repeated analyses at CLIM
** CLIM A = K1 samples
CLIM B = all other samples
-- not determined

MAP 84-2

Parts of NTS Map Sheets 11F/15, 11F/16, 11K/1, and 11K/2.

Nova Scotia Department of Mines and Energy

MAP 84-2

GEOLOGICAL MAP

OF THE

BOISDALE PENINSULA, CENTRAL CAPE BRETON ISLAND

CAPE BRETON COUNTY

NOVA SCOTIA

Sandra M. Barr and Jeremy R.D. Setter

Honourable Joel R. Matheson, Q.C., Minister
John J. Laffin, P.Eng., FEIC, Deputy Minister

Halifax, Nova Scotia
1984

Scale 1:100 000

kilometres 1 0 1 2 3 kilometres

Contour Interval 250 Feet

LEGEND

CARBONIFEROUS

GRANTMIRE FORMATION and **WINDSOR GROUP**

DEVONIAN

MCADAM LAKE FORMATION

CAMBRO-ORDOVICIAN

BOURINOT GROUP and *MACMULLIN, MACNEIL AND MCLEOD BROOK FORMATIONS*

LATE HADRYNIAN-CAMBRIAN

SHUNACADIE PLUTON	BOISDALE HILLS PLUTON	SPRUCE BROOK PLUTON	COXHEATH PLUTON
Leucogranite	Leucogranite	Dioritic to granodioritic rocks, granite	Dioritic to granodioritic rocks, granite
Granite	Microgranite		
Biotite granodiorite	Syenogranite		
Diorite and related rocks	Biotite granodiorite		
	Biotite hornblende granodiorite		
	Hornblende granodiorite		
	Diorite, quartz diorite, tonalite		

NOTE: Relative ages of plutons are unknown

LATE HADRYNIAN

FOURCHU GROUP

HADRYNIAN (OR OLDER)

GEORGE RIVER GROUP

SYMBOLS

Geological boundary (defined, approximate, assumed)

Fault (defined, approximate, assumed)

Bedding

Foliation

Felsic dyke

Sampled outcrop

Analyzed sample 1512

60°45' 40' 35' 30' 25' 60°20'

46°13' 10' 5' 46°00'

Boularderie Island

SE. ANDREWS CHANNEL

Long Island

Georges River Station

Georges River Inlet

Scotch L.

Rice Pond

Barra

Mackinnons Lake

Forrester Lake

Boisdale

Frenchvale

Gillis L.

Loon Lake

McAdams Lake

EAST BAY HILLS

East Bay

MacEachern Lake

Curry Lake

223

Contour Interval 250 Feet

LEGEND

CARBONIFEROUS

GRANTMIRE FORMATION and **WINDSOR GROUP**

DEVONIAN

MCADAM LAKE FORMATION

CAMBRO-ORDOVICIAN

BOURINOT GROUP and *MACMULLIN, MACNEIL AND MCLEOD BROOK FORMATIONS*

LATE HADRYNIAN-CAMBRIAN

SHUNACADIE PLUTON	BOISDALE HILLS PLUTON	SPRUCE BROOK PLUTON	COXHEATH PLUTON
Leucogranite	Leucogranite	Dioritic to granodioritic rocks, granite	Dioritic to granodioritic rocks, granite
Granite	Microgranite		
Biotite granodiorite	Syenogranite		
Diorite and related rocks	Biotite granodiorite		
	Biotite hornblende granodiorite		
	Hornblende granodiorite		
	Diorite, quartz diorite, tonalite		

LATE HADRYNIAN

FOURCHU GROUP

HADRYNIAN (OR OLDER)

GEORGE RIVER GROUP

NOTE: Relative ages of plutons are unknown.

SYMBOLS

Geological boundary (defined, approximate, assumed)

Fault (defined, approximate, assumed)

Bedding 40

Foliation 40

Felsic dyke

Sampled outcrop x

Analyzed sample 1512

NOTE: Funded by the Nova Scotia Department of Mines and Energy; Natural Sciences and Engineering Research Council of Canada; J.B. Tyrrell Fund of the Geological Society of London; and Acadia University Graduate Fellowships.

Some geological boundaries after Bell and Goranson (1938), Weeks (1954), and Kelley (1967).

Boisdale
Shunacadie
Benacadie
Christmas Island
Eskasoni
McPhee Island
Frenchvale
Loon Lake
McAdams Lake
Gillis L.
MacEachern Lake
Carrs Lake
Ben Eoin
Percy Allan Lake
Benacadie Pond
Brook
EAST BAY HILLS
BOISDALE HILLS
INDIAN ISLANDS
EAST BAY (BRAS D'OR LAKE)

Prince Edward Island
New Brunswick
Sydney
MAP AREA
NOVA SCOTIA
HALIFAX
Sable Island
0 50 100 150 km

46°00'
45°55'
60°45'
40'
35'
30'
25'
60°20'
5'

Nova Scotia Department of Mines and Energy

Map 84-2 to accompany Nova Scotia Department of Mines and Energy Paper 84-1